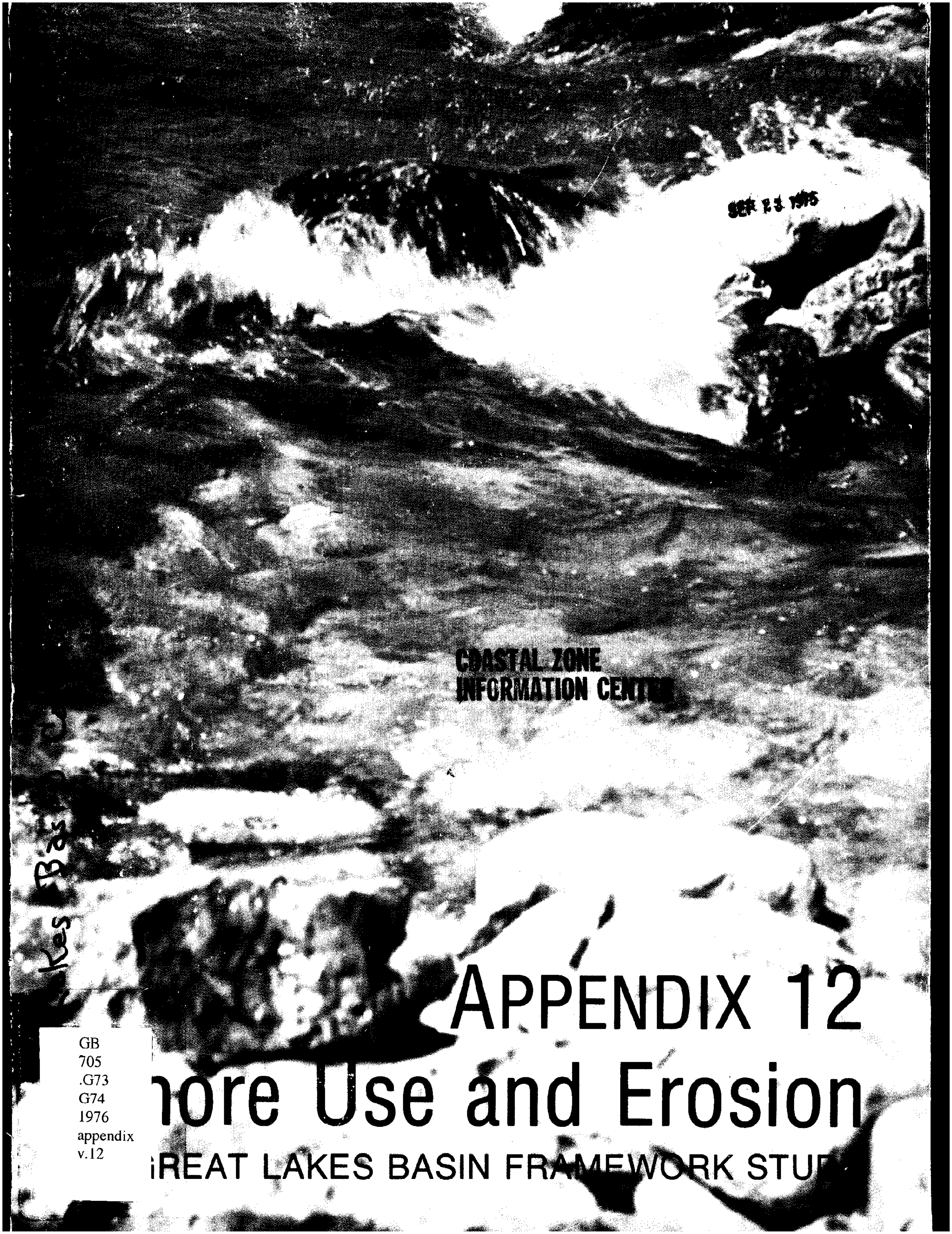

APPENDIX 12
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Great Lakes Basin Framework Study

APPENDIX 12

SHORE USE AND EROSION

GREAT LAKES BASIN COMMISSION

Prepared by Shore Use and Erosion Work Group

Sponsored by U.S. Army Corps of Engineers, North Central Division

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This appendix to the *Report* of the *Great Lakes Basin Framework Study* was prepared at field level under the auspices of the Great Lakes Basin Commission to provide data for use in the conduct of the Study and preparation of the *Report*. The conclusions and recommendations herein are those of the group preparing the appendix and not necessarily those of the Basin Commission. The recommendations of the Great Lakes Basin Commission are included in the *Report*.

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Appendix 2: Surface Water Hydrology
Appendix 3: Geology and Ground Water
Appendix 4: Limnology of Lakes and Embayments
Appendix 5: Mineral Resources
Appendix 6: Water Supply—Municipal, Industrial, and Rural
Appendix 7: Water Quality
Appendix 8: Fish
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Appendix 11: Levels and Flows
Appendix 12: Shore Use and Erosion
Appendix 13: Land Use and Management
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Appendix 21: Outdoor Recreation
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Environmental Impact Statement

SYNOPSIS

This appendix is a study of the United States shorelands and islands of the Great Lakes. Of the 3,470 miles of mainland shoreline in the United States portion of the five Great Lakes, 600 miles, or 17.3 percent, are publicly owned. The remainder, 82.7 percent, is privately owned. In addition, there are 245 miles of United States shoreline along the Great Lakes connecting waterways, the St. Marys River, the St. Clair River, the Lake St. Clair and Detroit River system, and the Niagara River.

Shorelands are the focus of development in the Great Lakes Region by virtue of their proximity to the Lakes and the opportunity they offer for waterborne commerce, water supply, and recreation. Primary factors determining the type of shoreland use and development in a given area are geographical location, accessibility, ownership, and shore type.

Structural development (industrial, commercial, and permanent residential) is predominant along lower Lakes Michigan and Huron, Lake Erie, and Lake Ontario. Industrial and commercial development is concentrated primarily in urban areas. Seasonal residential development is located primarily along the northern shorelands of northern Michigan, Wisconsin, and Minnesota away from the metropolitan concentrations of the lower Lakes.

Forested shorelands are almost exclusively confined to the northern areas of Michigan, Wisconsin, and Minnesota. Large tracts of wildlife and game preserves are located along many of the isolated lakeshore areas of Michigan, Wisconsin, and Minnesota and along the western Lake Erie shorelands of Ohio and Michigan. Both public and private interests administer these areas to provide habitat and cover for wildlife and to promote better hunting opportunities in the Great Lakes Region.

Located along the shores of the Great Lakes are the largest recreational areas in the Great Lakes Region, three national lakeshore parks, 67 State parks, and numerous local parks. Lake Michigan has approximately one-half of all designated recreation mileage along the Great Lakes shorelands. Lake Huron has the smallest number of miles of recreation shorelands of any of the Great Lakes.

Physical characteristics of the Great Lakes shorelands are as diverse as the development and uses associated with them. In this report, the physical characteristics are classified on the basis of 10 basic shore types. Lakes Michigan and Superior have the most diverse shore types, Lake Ontario the least.

High sands, 30 feet or higher, are found almost exclusively along the eastern shore of Lake Michigan in eastern Indiana and south and central Michigan. Sand dunes less than 30 feet high are located all along the Great Lakes, but the major concentrations are located along Lakes Superior and Michigan, primarily in the States of Michigan and Wisconsin.

Artificial fills are located primarily along the southern and western shores of Lake Michigan, the Lake Erie coast, Lake St. Clair, and along the Detroit River in the Detroit area.

While valuable fish and wildlife wetlands and marshes occur along Lakes Michigan, Huron, Erie, Ontario, St. Clair, and in the St. Marys River, the most extensive wetland areas are located along the west shore of Green Bay on Lake Michigan, in Saginaw Bay on Lake Huron, and in Lake St. Clair. Other major wetlands areas are located at the western end of Lake Erie and at Lake Ontario's outlet, the St. Lawrence River. Lake Superior has the least amount of wetlands of any of the Great Lakes.

Nonerodible high bluffs, 30 feet or higher, are located along much of the Lake Superior shoreline and in northern Door County, Wisconsin, on Lake Michigan. Nonerodible low bluffs, less than 30 feet high, are more widely distributed throughout the Great Lakes, although Lake Superior has the greatest number of miles of this shore type, followed by Lake Ontario. Nonerodible low plains exist generally on the three upper Lakes: Huron, Michigan, and Superior. This shore type is almost nonexistent on Lakes Erie and Ontario.

Erodible bluffs and low plains are found along each of the Great Lakes in varying degrees. Lake Michigan has the greatest number of miles of these shore types, which are located along much of the Lake. Lake Ontario has the least.

Much of the history and romance of the midwestern United States, tales of shipwrecks, Indian raids, and piracy, are linked to the Great Lakes islands. In addition to their historic value, the islands, even the many smaller unpatent islands, have significant recreational, scenic, agricultural, and fish and wildlife habitat value. Approximately 60 percent of the United States island acreage is publicly owned. Isle Royale, Michigan, is the only national park island. The Apostle Islands, Wisconsin, recently received Congressional authorization as a national lakeshore, and Michigan's Manitou Islands have been included in the authorized Sleeping Bear Dunes National Lakeshore. There are State parks on Rock Island, Wisconsin, and Mackinac Island, Michigan. Michigan's Little Beaver Island is a designated State game area and West Sister Island, Ohio, is a national wildlife refuge. Belle Isle, in the Detroit River, is an outstanding recreation area and is owned by the City of Detroit. Many other islands have historic, cultural, and environmental significance. Knowledge is lacking about the physical, environmental, and cultural characteristics and problems of the Great Lakes islands. Previous piecemeal studies have not included a comprehensive inventory and analysis of the characteristics and problems of the Great Lakes islands. A detailed, comprehensive study would be desirable for future island resource management and conservation.

Shore erosion is one of the major problems along the Great Lakes shoreland. While its major causes on the five Great Lakes include underground water seepage, frost and ice action, surface water runoff, and wave action, wind generated wave action causes the greatest erosion damage. Wave action works directly on the beach or at the toe of the bluffs eroding away clay, silt, sand, and gravel. The intensity of damage caused by wave action varies with the magnitude of the waves generated, the elevation of the undisturbed lake level, the temporary increase in that level generated by wind or barometric pressure gradient, and the erodibility and exposure of the shorelands.

Shore damage on the Great Lakes is massive. Seventy percent (2,500 miles) of the shore is erodible. Twelve hundred miles are subject to significant erosion, and 204 miles are subject to critical erosion, while approximately 335 miles are subject to flood damages. Economic losses occur because 50 percent of the shore is already developed, and an additional 30 percent of the shore may be developed by the year 2020. Continued erosion along developed shorelands will require extensive local protection works. Shore property, which is becoming more valuable, will be protected when the level of damage equals or exceeds the cost of protection.

Shoreland damages can be reduced if measures are taken to prevent the problem from increasing, advice and assistance are provided to owners of shore property suffering erosion damages, and more efficient lake level regulation plans are implemented. The only management techniques applicable to shoreland erosion problems are acquisition and regulatory controls. These measures will not reduce future losses of land due to erosion, but they can reduce or eliminate costly damage to structures built in the future. Management programs are highly desirable for relatively undeveloped shorelands, but land-use controls must be adequately supported and based on sound engineering and scientific data to be legally defensible. The general public and local officials must be made aware of the necessity of such controls and the procedures for implementation.

Section 1 of this appendix explains how to develop a shoreland management program. Erosion rate studies, flood plain information reports, and model zoning ordinances are needed to support land-use regulations.

Developed areas suffering erosion and flooding damages can be helped with a variety of engineering and planning techniques. The owner of shore property must be educated to evaluate his own situation and decide on a course of action for reducing shoreland damages. Often it is lack of attention to detail rather than lack of funds that leaves private shore property unprotected. Government must provide clear information. Information in Section 2, Coastal Processes and Shore Protection, can be of use here. Federal and State governments should assist in planning for shoreland reaches with conflicting demands or serious flooding and erosion problems.

In addition to erosion problems, other factors that must be considered in shoreland planning and management include shoreland alterations, waterfront blight, nonessential and conflicting uses, lack of historic preservation, lack of public access, encroachment on wetlands, sedimentation, and unplanned development. The planning techniques outlined in Section 3, Shoreland Management Measures, are applicable to areas requiring such studies.

Low cost shore protection projects, such as the State of Michigan's $370,000 erosion control demonstration project program, which is evaluating low-cost means of controlling erosion, must be constructed and evaluated. As millions of dollars are spent on shore protection measures on the Great Lakes, work should be evaluated and successes as well as failures should be documented.

Because of the very high cost of shore protection—unit costs average between $100 and $500 per foot—it is often impossible for private individuals to protect their properties. Some type of cost-sharing program for protection of private lands is needed.

FOREWORD

The Shore Use and Erosion Work Group of the Great Lakes Basin Commission prepared this report. Richard E. Carlson, U.S. Army Corps of Engineers, was appointed chairman of the Work Group by Raymond R. Clevenger, former chairman of the Great Lakes Basin Commission, on April 23, 1968. Subsequent appointments to the Shore Use and Erosion Work Group included representatives from each of the Great Lakes States, the U.S. Departments of Agriculture and the Interior, and the U.S. Army.

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INTRODUCTION

Study Purpose

Appendix 12, *Shore Use and Erosion*, contains an assessment of Great Lakes shoreland management problems, their causes, effects, and possible solutions. In the course of the study the Shore Use and Erosion Work Group, with the cooperating Federal and State agencies, developed a framework of information for future management of shoreland resources.

Relationship to Other Appendixes

This appendix should be used with other appendixes that provide information on basin and lake characteristics, including Appendix 3, *Geology and Ground Water*; Appendix 4, *Limnology of Lakes and Embayments*; and Appendix 11, *Levels and Flows*, which describe the Great Lakes system, the physiography of its basins, and the physical, chemical, and biological characteristics of the Lakes. Appendix 6, *Water Supply—Municipal, Industrial, and Rural*; Appendix 7, *Water Quality*; Appendix 8, *Fish*; Appendix C9, *Commercial Navigation*; Appendix R9, *Recreational Boating*; and Appendix 10, *Power*, describe those uses of Great Lakes waters.

Scope of Investigation

This study of the shorelands of the Great Lakes (Figure 12–1) includes the mainland shores of the five Great Lakes, their connecting waterways, Lake St. Clair, and the major islands or island groups. The Great Lakes shoreland covers the area one-half mile inland and three miles off the shoreline. Shorelands include the land, water, and land beneath the water that are in close proximity to the shoreline of the Great Lakes, connecting waterways, and islands.

Information concerning the coastal zone of the Great Lakes given in this appendix is of framework quality, such as is needed for the broadest level of planning. The report contains an inventory of shoreland resources, use, and ownership, as well as a planning framework for the Great Lakes shorelands and a discussion of coastal processes and shore protection works. A procedure for managing shoreland resources, a statement of agency programs in the shoreland zone, an analysis of Great Lakes problems and solutions, and a strategy for Great Lakes shoreland damage reduction are also included.

The inventory of shoreland resources, development, and ownership is described in this Introduction, which also describes the historical development of the Great Lakes shorelands. Data are presented on maps and tables in the two attachments to this report.

Section 1, Planning Framework for the Great Lakes Shorelands, explains how to develop a management program for the shore region of the Great Lakes.

Section 2, Coastal Processes and Shore Protection, concerns information on the physical factors that cause shoreland erosion and inundation such as storms and wave action, lake levels, shoreline exposure, beach materials, and beach profiles. Methods and procedures used in the design of shore protection structures are also included in Section 2.

Section 3, Shoreland Management Measures, describes the elements of a shoreland management program. Procedures for listing existing and potential uses of shore property and developing general plans for future shoreland uses, based on specific objectives and goals are shown.

Section 4, Agency Programs for Shoreland Damage Prevention, gives a brief overview of available State and Federal programs.

Section 5, Great Lakes Analysis, of Shore Property Damage discusses existing and projected use of shoreland resources, damage potentials, and alternative plans for reducing damage for each Great Lake.

Section 6, A Strategy for Shoreland Damage Reduction, suggests a framework of studies, data collection, and research activities aimed at reducing shore damages.

The base line for this appendix, with respect to shoreline conditions and lake levels, is 1970. While it is not practical within this framework

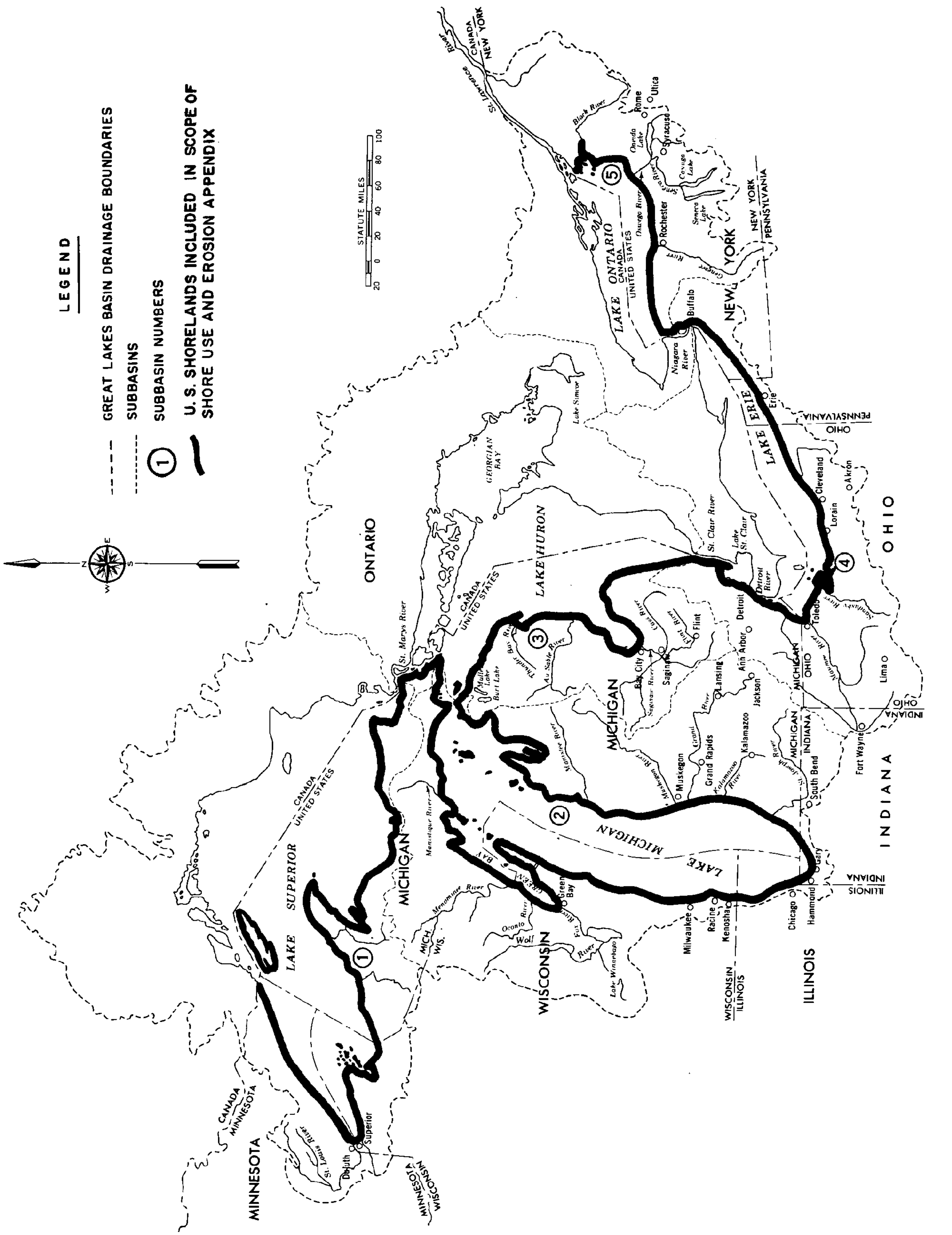

FIGURE 12–1 Great Lakes Shorelands

study to obtain detailed field data on shore erosion and flood problems that resulted from high lake levels in 1972, 1973, and perhaps 1974, a summary of the general situation follows.

Lake Levels

Lakes Superior, Michigan, Huron, and Ontario experienced levels within one foot of the all-time record high in the summer of 1973. Lakes Erie and St. Clair exceeded previous high lake levels by more than one-half foot. Indications are that lake levels may continue to be high in 1974.

Shorelands

High lake levels create a potential for severe damage along the Great Lakes shorelands. When storms coincide with abnormally high waters, shorelands are subject to severe flooding and erosion.

Of the 3,470 miles of mainland shoreline along the Great Lakes, 1,196 miles are subject to significant erosion, 290 miles are subject to flooding, 328 miles are protected, and 1,656 miles are noneroding under base-line conditions.

Based on conditions of high lake levels in November 1973 and on data readily available from State agencies, similar information follows: significant erosion, 1,770 miles; subject to flooding, 600 miles; protected, 500 miles; non-eroding, 600 miles.

The only consistent monetary estimate of shoreline damage is that compiled for the 1951–52 high water, which estimates shore property damage at $61 million. Wave action accounted for $50 million and flooding caused damages of $11 million. An approximation of total damage for the 1973–74 period would be at least several times greater than that of 1951–52.

Programs

The Corps of Engineers, in cooperation with State and local agencies, has provided temporary flood protection to shoreline areas under available flood emergency authorities. Flood protection has been provided to approximately 130 communities at a cost of $24 million. It is estimated that flood damages totaling approximately $88 million were prevented by this emergency protection.

The Federal Regional Council, Region 5, has adopted an objective to "support reduction in Great Lakes shoreland damage through a strategy of planning and programs created in concert with the Great Lakes Basin Commission and Federal, State, and local agencies."

Inventory of Shoreland Resources

In preparing this report, maximum use was made of information gathered by the Shore Use and Erosion Work Group from State and Federal agencies.

An inventory of existing shoreland development, physical characteristics, and environmental values has been made for the entire study area. Inventory data, compiled from aerial photographs, U.S. Geological Survey quadrangle sheets, and existing international, Federal, State, local public, and university reports and publications, are arranged on base maps having scales of 1:62,500 and 1:63,360. No extensive field surveys were made for this study.

Data are summarized in Attachment B on a set of shoreland strip maps, prepared at a scale of 1 inch equals 15 miles (1:950,400). Strip reaches were selected on the basis of the Great Lakes Basin planning subareas. The maps are broken at State lines and subdivided for clarity.

The following items were identified in the shoreland inventory:

(1) shoreline mileages

(2) existing shoreland use (eight categories)

(3) shore types (10 types)

(4) beach zone material (three types)

(5) public ownership (Federal, State, local)

(6) significant fish and wildlife, ecological, and natural areas

(7) erosion and flooding areas

(8) locations of public beaches, harbors, electric power generating stations, water intakes, and waste outfalls

Great Lakes mainland shoreline mileages were established both for the International Joint Commission study, *Regulation of Great Lakes Water Levels* and for the *Great Lakes Basin Framework Study*. Reference markers at one-mile intervals have been identified on U.S. Lake Survey charts having scales of 1:80,000 to 1:120,000. These established mile markers provide a reference system for this report and future shoreland work. The shoreline mileages presented in this report may differ from other published mileage figures because of differences in mapping techniques and the type and scale of base maps used. It should also be noted that absolute shoreline mileages will change, because of fluctuating lake levels, new lake fill constructions, and erosion and accretion processes.

Information concerning islands of 10 or more acres was compiled by the Bureau of Outdoor Recreation (BOR) from Island Inventory Worksheets which were completed by various Federal and State agencies. A sample of the worksheet and the island inventory are provided in Attachment A.

The following items are identified in the island inventory:

(1) type of ownership (public or private on an acreage basis)

(2) percent developed

(3) accessibility (yes or no)

(4) type of topography (level, rolling, mountainous or other)

(5) type of cover (grass, forest, shrub, swamp, cultivated, naturally barren, water, developed, and other)

(6) shore type (beach, bluff, swamp, and other)

A comparable inventory of shoreland development, physical characteristics, and erosion problems along the Great Lakes mainland shores of Canada, completed in the late 1960s by the Canadian government for the International Joint Commission study, *Regulation of Great Lakes Water Levels*, is also available. The Canadians, who made extensive field investigations in completing their inventory, used mapping procedures and definitions that differ slightly from those used in this report.

Disparities also arise because the techniques used to identify mileages in bays and wetlands and to choose points of division between the Great Lakes and connecting channels vary.

Existing shoreland use based on 1969–1970 conditions was mapped according to eight categories: residential, commercial, industrial, public buildings and related lands, agricultural and undeveloped lands, recreation, fish and game lands, and forest lands. Definitions of these categories are found in the Glossary.

In an effort to categorize the land forms and topography of the Great Lakes shorelands, 10 basic shore types were defined:

A Artificial Fill Area.
HBE Erodible High Bluff, 30 Ft. or Higher.
HBN Non-Erodible High Bluff, 30 Ft. or Higher.
LBE Erodible Low Bluff, Less than 30 Ft. High.
LBN Non-Erodible Low Bluff, Less than 30 Ft. High.
HD High Sand Dune, 30 Ft. or Higher.
LD Low Sand Dune, Less than 30 Ft. High.
PE Erodible Low Plain.
PN Non-Erodible Low Plain.
W Wetlands.

Materials in the beach zone were also identified as rock or unconsolidated material such as sand and gravel.

Significant fish and wildlife, ecological, and natural areas along the Great Lakes shorelands are also shown on the maps. Basic information for this portion of the inventory was taken from the working maps of the Department of the Interior National Estuarine Study completed in 1969 with the cooperation of various State agencies. This basic data was supplemented by an inventory of critical bird nesting and migration areas completed specifically for this report by Dr. William C. Scharf, Northwestern Michigan College, Traverse City, Michigan.

Reaches of mainland shore subject to erosion and flooding have been identified as areas subject to erosion generally protected; critical erosion areas not protected; noncritical erosion areas not protected; reaches of shore subject to lake flooding; and reaches of shore not subject to erosion or flooding. This identification was based primarily on information available from the International Joint Commission study on water levels of the Great Lakes and the Great Lakes Region Report to the National Shoreline Study. Other problems and conflicts associated with the Great Lakes shorelands are also identified and discussed in the report. Data used to identify public beaches, water intakes and waste outfalls, harbors, and electric power generating stations were taken from the International Joint Commission study, *Regulation of Great Lakes Water Levels*. This data was originally compiled by BOR, the Environmental Protection Agency, and the Corps of Engineers.

An inventory of the major islands and island groups in the five Great Lakes, Lake St. Clair, and the connecting waterways has also been made, using basic information compiled by the Bureau of Outdoor Recreation for its report, *Islands of America*.

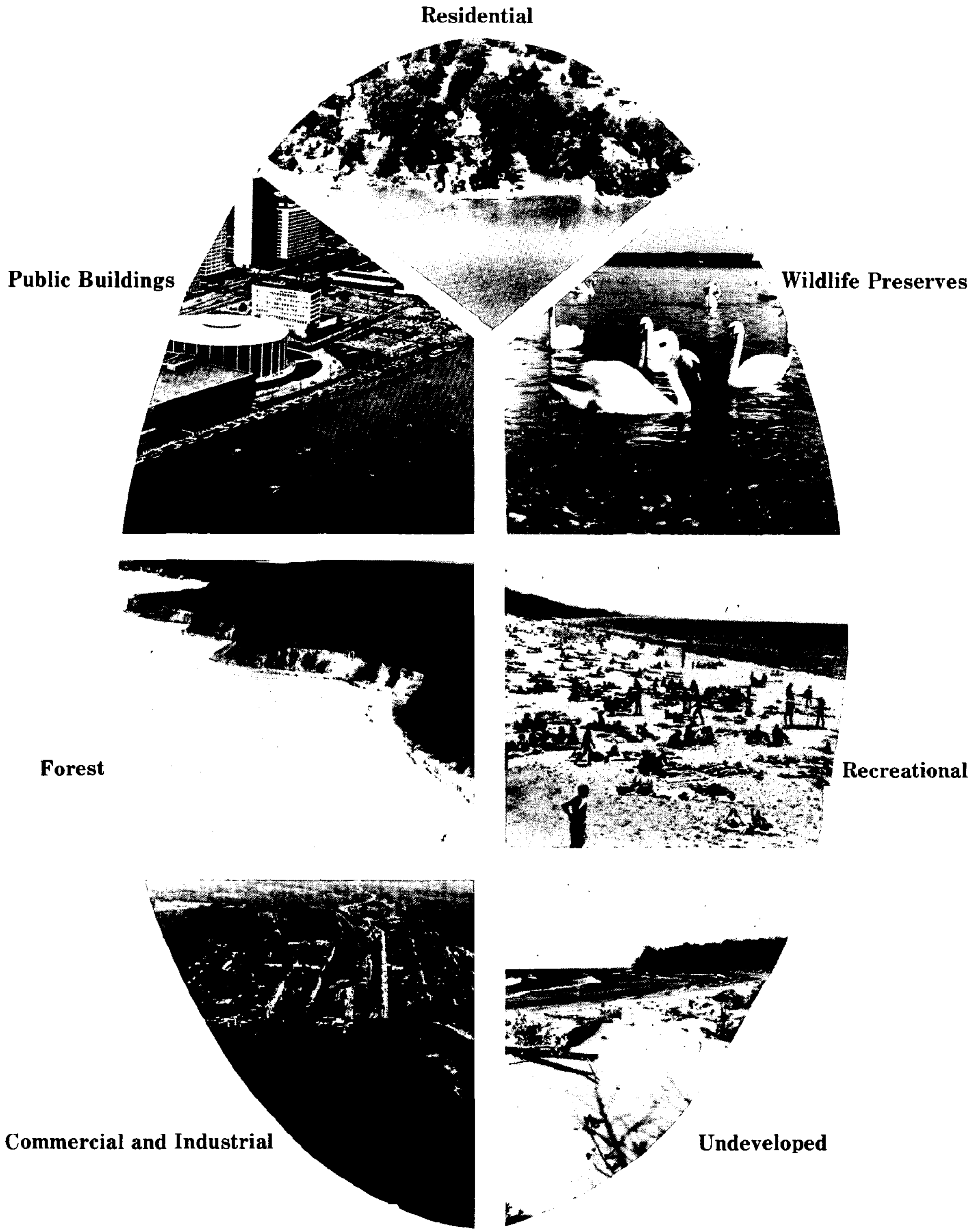

FIGURE 12–2 Typical Shore Uses

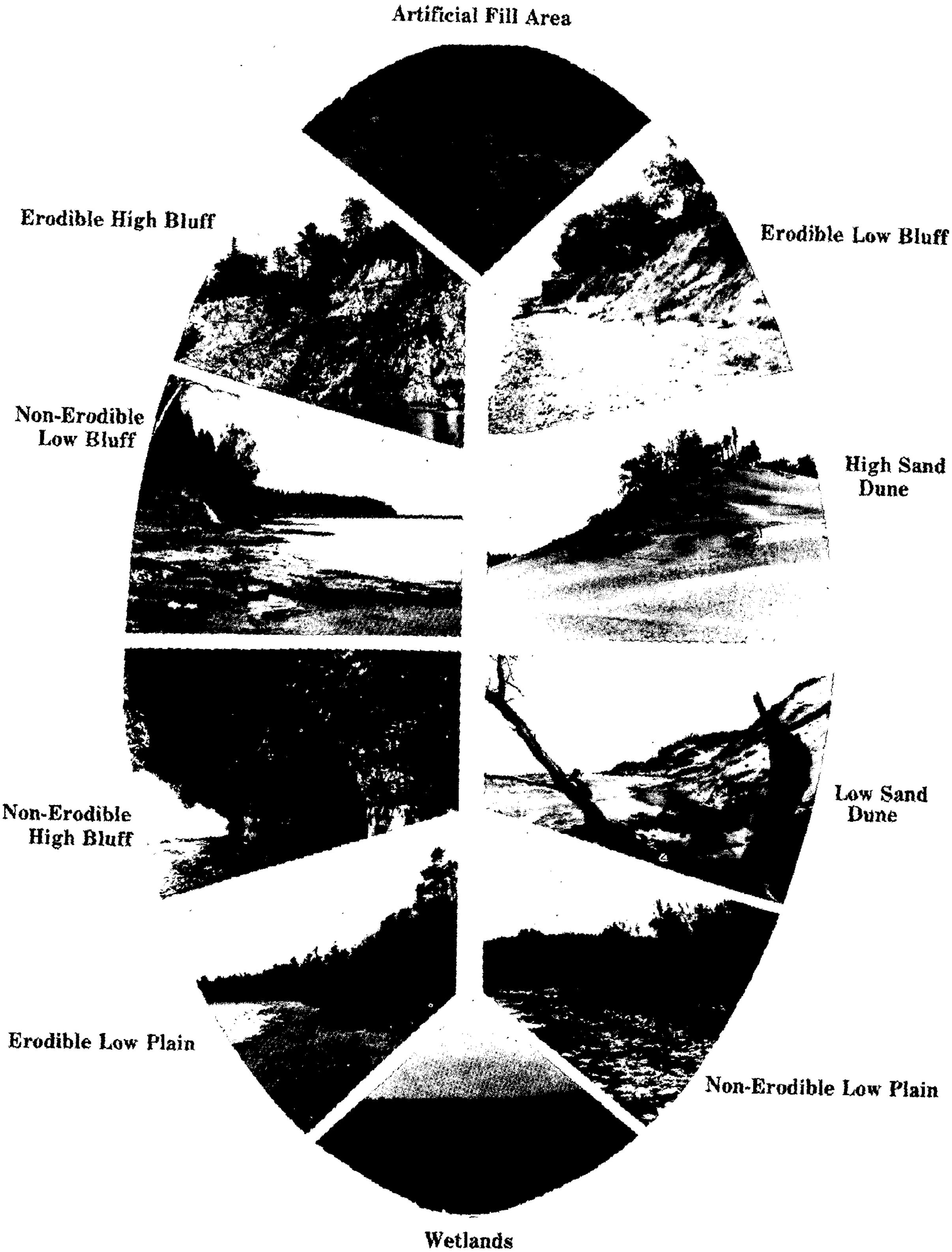

FIGURE 12-3 Typical Shore Types

Historic Trends in Shoreland Development

The Great Lakes basins were created and modified by glaciation over thousands of years. The Wisconsin Glacier, the last of four known glaciers to cover the Great Lakes and other parts of the North American continent, was primarily responsible for the present configuration of the Lakes. The Great Lakes now contain one-half of the fresh water in the world. The only natural outlet of the Lakes is eastward through the St. Lawrence River to the Atlantic Ocean.

Because the amount of the earth's water remains constant, geologists reason that during the glacier age so much water was trapped in the ice that the levels of the oceans dropped and an ice and land bridge formed across what is now known as the Bering Strait. Small nomadic bands may have crossed the land bridge from eastern Siberia to the North American continent, but the Great Lakes area was probably not occupied until after the last glacial retreat when Indian cultures, many of which existed by fishing for whitefish along the shores of the Great Lakes, subsequently established themselves.

Although discovery of the Great Lakes is generally credited to Samuel de Champlain, most historians admit that his scouts were probably the first of the early explorers to see the Great Lakes. The French entered the Great Lakes in the early 1600s by a wilderness route from the St. Lawrence and Ottawa Rivers into Georgian Bay and Lakes Huron and Superior. By taking this route they bypassed the hostile Iroquois Indians along the lower Lakes and Niagara Falls at the head of Lake Ontario.

The Franciscan, Sulpician, and Jesuit missionaries carried evangelism into the wilderness, while canoe caravans brought back a wealth of fur pelts. Each spring trading posts at Green Bay, Wisconsin, and Grand Portage, Sault Ste. Marie, and Michilimackinac, Michigan, sent the previous winter's catch back over the Ottawa River route to the St. Lawrence.

The first ship larger than a canoe to navigate the Great Lakes was built by LaSalle near Niagara Falls in 1679. This square-rigged vessel, called the Griffin, carried tools and supplies on its first cruise to Green Bay, where these items were unloaded and a cargo of fur pelts taken on. The ship was lost without a trace on the return trip, the first of many Great Lakes vessels to disappear in the icy waters. During the next 100 years canoes and plank bateaux continued the fur commerce. Detroit, Michigan, grew as a commercial port and larger sailing vessels on the lower Lakes began to replace the canoe traffic. Shipbuilding yards at Cleveland, Ohio, and Detroit, St. Clair, and Bay City, Michigan, produced the growing sailing fleet. The Erie Canal brought thousands of immigrants to Buffalo, New York, where they embarked for various areas of the Midwest. As these immigrants cleared the forests and settled their farms, a growing stream of grain flowed to the East through Chicago, Illinois; Milwaukee, Wisconsin; and Duluth, Minnesota.

In the middle of the 19th century, while copper was being mined from the Keweenaw Peninsula, Michigan, lumberjacks began clearing the vast forests along the shorelines of Lakes Huron, Michigan, and finally Superior. Billions of board feet of timber were sent down tributaries to the Great Lakes. As a result, towns and harbors grew overnight and sawmills left huge, yellow dunes of sawdust on the shore. The lumber industry's discarded slabs and edgings were used as fuel for pumping brine out of Saginaw sand and for evaporating salt. Limestone deposits were the source of the Portland cement industry on upper Lake Huron, while tons of ore from the Vermilion, Marquette, Menominee, Geogebic, and Mesabi iron ranges were sent through newly built harbor towns via schooners, steamers, and, later, huge freighters.

During the years of rapid development along the Great Lakes, northern and western ports were built on the upper Great Lakes to transport raw materials to new harbors in the lower and eastern lake areas where these goods were processed. With the opening of the St. Lawrence Seaway came profitable ocean commerce, which encouraged foreign trade.

Industries thrive at many major cities and ports around the Great Lakes. Much of the shoreland between these major cities and ports has been developed into attractive residential and recreational areas. Some commercial fishing and small shipbuilding trades continue to thrive, and fruit-growing and agricultural lands occupy some of the more rural shoreland areas. Significant portions of the shorelands have been set aside as wildlife areas.

Section 1

PLANNING FRAMEWORK FOR THE GREAT LAKES SHORELANDS

1.1 Introduction

The planning framework for the Great Lakes shorelands suggested in this section combines concepts formulated by individuals and organizations. Its purpose is to provide an example that can be followed in developing a management program for the shore regions of the Great Lakes.

This framework acknowledges that citizens of the Region recognize the value of the Great Lakes shorelands as an important regional resource in terms of amenities and aesthetics. Consequently, the central theme of this program is that shorelands should remain as near their natural state as possible. It is not a question of whether or not the shorelands should be used, but rather how to use them. The plan requires that future uses be based on measures and practices of land and water uses and structural needs that optimize scenic, recreational, and biotic value on the one hand, and shore stabilization on the other.

The framework is laid out in a series of separate, but interdependent parts:

(1) the main element—a summary of the planning concept and guidelines

(2) the physical setting—a description and inventory of the natural, cultural, and physical characteristics of the shorelands

(3) legal frameworks—an analysis of existing management tools and new approaches to be considered

(4) institutional arrangements—an analysis of existing and potential political arrangements that could be used to manage the shorelands

Management of the shorelands is only one aspect of regional land use. Shoreland planning must take into consideration necessary elements of both regional and shoreland planning, such as overall population and economic forecasts, organizational and institutional arrangements, allocation of land resources to meet specific purposes, and transportation plans. Questions of growth or no growth, or preferred levels of growth, can best be answered in a regional context.

Fortunately, there are many Great Lakes regional planning entities, such as planning commissions that provide regional planning guidelines for the specific regions they serve. Those planning aspects are not included in this framework.

If the shores are to be preserved, meaningful measures must be adopted before development occurs. Because pressures for shoreland use will be extremely intense in the next few years, this program is based largely on existing statutory mechanisms.

The objective of this section is to develop a rationale for common State management of the valuable shorelands of the Great Lakes. This type of rationale is necessary because the unity of the Great Lakes system is contradicted by the political boundaries that define the mechanisms available for resource management.

Market prices and sophisticated landscape analysis show that the waters and shorelands of the Great Lakes are very valuable to man and to the biotic communities that share the Region. Beaches, scenic bluffs and cliffs, sheltered embayments, and shallow bays and marshes offer aesthetic enjoyment to residents and visitors alike, great money-making potential in commerce and industry, and a habitat for abundant sport fish and wildlife. Shorelands are eroded, leveled, filled, farmed, built on, or left in forest, dune, and field, depending on who owns the shorelands and whether or not society recognizes its responsibility for the common resources as seen from the water and from the landward approaches.

In the Great Lakes Region the overwhelming majority (83 percent) of coastline property is owned by private individuals, associations, and corporations. Except for parks, wildlife management areas, forests, and occasional development zones under municipal, State, and Federal jurisdiction, the interest of the general public is expressed only through general restrictions designed to protect the health and welfare of all people. Controls, frequently called the police powers, stem from the retained sovereignty of the States. Yet each of the eight States differ in their delegation of power to subdivisions of the State, the manner by which environmental protection statutes are administered, and in their attitude toward developing the Great Lakes shorelands.

Shorelands extend beneath the surface of the Lakes. Without exception, States exercise complete sovereignty over submerged lands. The dividing line between individual dry land resources and common resources is usually the ordinary high water mark as referenced to the International Great Lakes Datum.

General management guidelines concerning many aspects of the shorelands, including erosion potential, should be prepared for these valuable resources. Guidelines are presented in this section for the 10 physiographic shore types defined in the Introduction. Activity oriented modifications of the water, the submerged land, and the terrestrial portions of the shorelands were arrayed against the 10 types of shoreline found in the Great Lakes. The resulting cells were used to analyze comparative State controls that might be predicated on differences in shoreland resources, the effects of development, design of developments compatible with the natural characteristics of the shorelands, and general policies or action that should be taken by the States.

The degree of State and local intervention in deciding the type and design of land and water use in the shoreland zone depends to a large extent on Statewide benefits accruing from these sources. The first portion of this section scans the field of value and value determination in hopes of standardizing application of police power in the eight States.

1.1.1 Value Framework for Resouce Use Controls

Lynton K. Caldwell, an architect of the National Environmental Policy Act, has said in his article "Environmental Administration" that:

> To deal effectively with America's environmental problems it will be necessary first to modify prevailing assumptions regarding the nature of social responsibility, the scope of public and administrative authority, and the level of professional and institutional competence required.

He makes the point that:

> There is more to the problem of organizing public authority and responsibility than perceived, and, because of the mistaken, self-interest of groups and individuals . . . people frequently do not act in their actual self-interest. They are often locked into behavior patterns, assumptions, and responses that cannot serve them well.

Implicit in the guidelines for future development of the Great Lakes shorelands is the premise that a public body representing the interests of society will encourage individuals (including corporations) and other public agencies to adhere to the guildelines. In this framework the guidelines suggest the maintenance of current proportions of shoreland commitment, although conflicting points of view are held by segments of the population.

Conventional economic analysis measures supply-demand-price relationships to determine the worth of resources, but such simple relationships do not adequately register all the values inherent in such increasingly scarce resources as shorelands.

In a democratic society, public decisions begin with individual and group perceptions of self-interest, i.e., individual and group value systems. In order to use a value structure as a control on the use of shoreland resources, one must describe the issues, establish relationships between values and administrative decisions, and assess the implications for coordinated State action.

1.1.1.1 Description of Issues

While there is very little quantitative data on value accruing to alternative use patterns of shoreland, some work has been initiated in structuring and recording values for the equally general fields of environmental goods and services, wilderness, and outdoor recreation. The relationship between environmental quality and perceived value is very close. In the socioeconomic realm, factors that significantly affect the analysis of value for environmental goods and services, outdoor recreation, and wilderness apply equally to the analysis of the shoreland control issue.

A major problem with discussing the value of environmental quality (amenities and aesthetics) is that a better environment yields no tangible returns. Because benefits are intangible, the analyst is incapable of defining options, let alone evaluating relative advantages or disadvantages of any options presented unless he interprets economics as it was interpreted in *Wilderness and Recreation —A Report on Resources, Values, and Problems*, that is, as a discipline that:

> . . . involves choice among the alternatives to maximize some kind of net return, and the net return can include aesthetic satisfaction.

In the same book, a study team from the Wildland Research Center of the University of California at Berkeley argued in 1962 that:

> . . . from the point of view of economic analysis, the services obtained from 'tangibles' and 'intangibles' are quite comparable; both can be measured by what people are willing to give up to obtain them.

Klausner agrees with this point of view in his article "Thinking Social-Scientifically About Environmental Quality." He advances the argument for social action in these terms:

> Today, we are beyond the need for technical documentation. . . . It is time to speak of social solutions. At this point we stumble in darkness. We need documentation on society and its environment. . . . One thing is clear. Research on the social problems should not be formulated in terms of physical environmental concepts but in terms of sociological concepts. We need new ways of thinking about social perceptions and social organization under changing physical environmental conditions.

Then he says:

> The concepts of economics refer to aspects of [these] human actions which, in turn, rest on certain attributes. . . . Economic analysis will deal with the relation between willingness to pay (demand) and willingness to labor to produce or transport some amount of the commodity (supply) . . . that is, with the relations between two social acts which take place with reference to the physical environment.

Most decisions relating to the allocation of resources, including all aspects of land, labor, and capital associated with environmental goods and services, are made in the market place, a mechanism that has served society very well by effectively allocating resources. Klausner's view is supported by Krutilla and Knetsch who state the value issue in their article "Outdoor Recreation Economics" as follows:

> The operational definitions of the value of outdoor recreation is simply the individual user's willingness to pay for the use of resources rather than go without the opportunities afforded.

They contend, "The criterion of willingness to pay is fully consistent with the evaluation of all goods and services provided by a market system. . . ."

Concurring with the Outdoor Recreation Resources Review Commission wilderness reporters, they contend that, in the case of outdoor recreation, there are major difficulties with allocative efficiency of the market and the effectiveness of available measurements:

> . . . although economic value of outdoor recreation is comparable to that of other resource uses, the demands are not registered in the market, (and income distribution must be taken into account) if a benefit-cost criterion is to be meaningful in application at any particular time in any particular area. . . .

There are two problems with measurement. Technical problems arise when methods are needed to record the actual use made of outdoor recreational opportunities and the effect of particular environmental characteristics on the enjoyment of them. Conceptual difficulties occur when measurements of the users, no matter how technically accurate, fail to register the feelings of those who are interested but do not participate. The Wildland Center's wilderness study team adopted the idea of "option demand" which they defined as a segment of the general population who willingly pay for the allocation of resources to wilderness even though they don't use it because they receive an adequate return from simply knowing wilderness is there. Krutilla and Knetsch rely on Musgrave's idea of "merit wants" to describe the desirability of allocating inner city space to provide recreation opportunities for the economically disadvantaged.

Demands and values for resources, which are now committed or could be committed in the future to various uses in accord with existing land and water characteristics, can be brought satisfactorily into a market framework by the use of proxies for price. Much early work in this area was done by Marion Clawson of Resources for the Future, Inc., and by Andrew Trice and Samuel Woods as consultants to the California legislature. The use of distance as a proxy for price has been refined in repeated field applications by Knetsch and others.

The result is the emergence of a three-part resources value structure that is useful for planning and decision-making. The elements are:

(1) values assigned by the market place—supply, demand, and price

(2) construction of demand curves by using proxies for price and carefully correlating these surrogates with quantities offered

(3) value judgments expressed through social (political) mechanisms.

1.1.1.2 Relationships Between Values and Decision-Making

There are too many externalities in the market place for it to be of use in determining shoreland resource use. The market performs well as long as goods or services can be divided and offered for exclusive use of a purchaser, who realizes, weighing all other competing opportunities to use his money, all the benefits or losses attached to the transaction. Decisions based solely on market forces can be expected, for example, to favor waste disposal methods that cost the individual firm or municipality the least. The discharger does not have to include the costs downwind or downstream resulting from his actions. Similarly, the erection of structures visible to highway travellers entering Grand Haven or to boaters cruising offshore near Chicago affects many more persons than the owner of the property on which the structure is built. As Crutchfield has observed in *Socio-economic, Institutional and Legal Considerations in the Management of Puget Sound:*

> . . . economic and political choice does not reflect accurately the strength of people's desire for preservation of environmental quality and of certain types of living organisms.

Some politically dominant groups confuse market-oriented benefits enjoyed by a few persons with benefits to the public at large. This is particularly true at the local level where the business community and elected public leadership are closely tied. To redress the situation, levels of government must respond to the values and interests perceived by the larger society.

Distribution of responsibility among individual, local, State, and Federal levels is one of the most difficult questions to settle in the United States. Distribution of decision-making powers should be dependent upon the cost incurred or benefits received from the decision made.

A township or county government may find it advantageous to fill its marshes to further the development of housing, industry, or commerce. While the marshes have not made apparent contributions to the welfare of the residents of the local jurisdiction, the new activity will benefit the residents, some very directly. Decisions made on similar grounds by each jurisdiction along a coastal reach would eliminate all coastal marsh, leaving local residents apparently unaffected, while perhaps an entire State or portions of several States lose diversity, a major part of the natural biologic productivity of the coast, and other wetland contributions such as storm protection. An authority that is able to comprehend the total benefits and total costs of a coastal system encompassing all individuals and jurisdictions should manage those aspects of resource use that cause benefits or losses beyond local interests.

Costs accepted by the State should be net. Local interests should pay the cost of all actions needed to protect marsh, e.g., land acquisition, closures, or rehabilitation, that will result in enhanced local earnings from tourists, from commercial and sport fisheries, or from other growth in the service sector. Glacken in his article "Man's Attitude Toward Land," makes a specific case that:

> The influence of tourism might be conservative enough to challenge economic and practical (local) interests, those who prefer a dam to the canyon, filled land for apartments to present bay shores.

Data must demonstrate which benefits and losses are local and which have wider distribution.

Present use of Great Lakes shorelands is largely a reflection of a market equilibrium, i.e., the land and nearshore subsurface use patterns reflect the time value structures of individual firms and agencies. Concern for more generally realized time values could be demonstrated by public acquisition of shoreland for recreation and wildlife management areas, by exercise of the police power of the State with respect to flood plains and lake shorelands in Wisconsin, Minnesota, and Michigan, and by marking and protecting historic sites and buildings, but even these expressions of widespread values are deficient. Parks and historic sites are acquired at fair market prices, rather than at the value perceived by those from whom the land is acquired. This is justified, according to Glacken, on the practical economic grounds of assumed local tourist benefits. Also, use of flood-prone lands and protective dunes is restricted as though Statewide values were identical to local values. Apparently no attempt has been made to determine if those who have given up high values (landowners and local governments) have been adequately compensated for the benefits received or whether the benefits have, in fact, been received by some third party. There has been little thought to transferring payments from the State or Federal governments to local governments to equalize the value framework. The value assigned by society to the rock cliffs rimming Lake Superior, the high dunes of Lake Michigan, and the low erodible flats of Lake Erie is represented by development now occupying the shorelands. Prices, economic conditions, market distances, historic precedent, the degree of concern expressed by local governments, the interaction of State and local governments, and the desires of landowners and buyers to retain the values they have paid for are reflected in the existing regional use pattern.

Current land use in resort areas like St. Marys River, Grand Island, Harbor Springs, and White Lake, Michigan, seems to contradict, but in fact reinforces, the proposition. The resorts date from the nineteenth century when lake steamers criss-crossed the Lakes. The enclaves were based on water transport and isolation from surrounding communities. The value perceived by the present owners for these choice sites, and their ability to pay for it, has effectively withheld the lands from the market. They are not willing sellers even if there are willing buyers. There are no public policies designed to coerce owners to convert properties to other uses or to encourage owners to maintain them in their present state. Reliance on the market to guide resource allocation is seen in degraded water quality conditions, leveled dunes, and rundown waterfronts, as well as in the charm of the old resort areas. Tourism seems too often to be the only recognized reason for local government concern for the quality of coastal environments in the Great Lakes. Even though it is assumed that tourist benefits are tied to environmental quality, no work has been done to establish and measure surrogates for tourist values. The need is acute for such values that would be comparable to market-determined returns from investing in a variety of public facilities, such as the highway network. Three factors influence differences in perceived values: interest groups, proximity to problems, and time. Groups form according to professional, business, or leisure interests. Organized water users, lakeside landowners, resort owners, ship owners, canoeists, and wilderness hikers favor uses that will directly improve what they prize most highly. Differing personal interest accounts for individual and local government decisions to fill the marsh lands in the example offered earlier. Collectively people favor expansion of nuclear electric generating capacity as long as the plant is not in their town. Collectively they favor natural dunes as long as no one stops them from leveling and building on the dunes they own. Lastly, conditions change with time. The Mesabi Range was valuable to Indians as a seasonal hunting ground, to European immigrants as a place to clear forests and farm, to industrial society as a source of iron ore, and to an affluent society as a place for recreation. Perhaps future generations will find it valuable for other reasons.

1.1.1.3 General State of the Data

Data to evaluate the market—actual and proxy—and social values that would guide the use of Great Lakes shoreland are lacking. Basic research is needed in the following areas:

(1) Market Values: The market value of real estate in flood plains and other components of the shorelands, the bulk of which is owned by private individuals and subject to disposition according to market rules (willing buyer and willing seller), is constantly changing.

(2) Proxies for Market Values: Information about the origin of tourist-recreation visitors in the various Great Lakes shoreland regions, their characteristics, and the impact of their spending is available, but it is not sufficiently uniform nor sophisticated enough to permit inter-regional comparisons, or to show the marginal amount and distribution of benefits derived from proposed implementation of shoreland development guidelines.

(3) Perceived Values: There are only a few cursory surveys of resident attitudes toward use of Great Lakes shorelands. Better information about local "option demand" and "merit wants" is needed.

(4) Development-Structure Alternatives: Systematic data on alternative structure forms, effect of alternative structure forms, effect on perceived values are almost totally lacking. There is a clear need to systematically identify and assign rank values to alternatives within each development category (e.g., alternative marine structural forms *vis-à-vis* the area of marsh to be filled). These data would aid in defining trade-off considerations and in promoting the optimum alternative available for any approved development action. The guidelines which follow point out the need for such further research.

While research to determine market values and appropriate surrogates will be rewarding for overall environmental planning, research in environmental response will be particularly useful for amenity and aesthetic concerns. An environmental response inventory has been devised in the Institute of Personality Assessment and Research of the University of California at Berkeley. The inventory, according to Kenneth Craik's article "The Environmental Dispositions of Environmental Decision-makers," consists of:

> . . . 218 items expressing various ways in which persons may relate to the everyday physical environment. In completing it, an individual simply indicates whether each item is descriptive of his view and typical behavior.

1.2 Planning Concept and Guidelines

The waters and shorelands of the Great Lakes are very valuable to man and the biotic community that share the Region. The corridor of shore waters, shoreline, and upper shoreland that encircles the Great Lakes possesses indisputable scenic, recreational, fish and wildlife, and general amenity values. Two objectives have shaped the format and content of the suggested guidelines for the use of the resources within this corridor:

(1) to recommend a method by which shore type analysis shapes land-use and water-use management policies

(2) to recommend measures and practices for each group of land and water uses and structural needs that would optimize scenic, recreational, and biotic values on the one hand, and shore stabilization on the other

Within each shoreland regulatory district or zone, the approach to wise conservation and land and shore use is two-fold. It is necessary not only to determine the compatibility of the proposed use or activity with the landscape, but also to select a layout and architectural and infrastructural design for any approved use or activity that will best harmonize with the resources of the shore. Harmonization implies careful conservation of resources for the purpose of maintaining long-term productivity in the environment. If, for example, a shoreland skyline is expropriated by a single high-rise hotel, slab-shaped and sited lengthwise along the shore, the view of the lake will be lost to other sites which lie inland.

Unless a large building is set back from the shore, the attractiveness for boaters and beach users of a predominantly natural shoreline is unnecessarily diminished. A typical solution is to turn the thin end of the building towards the lake. This sets the building back from the shore so that it merges harmoniously with the landscape. This also permits all the building's occupants, not just half, a view of the shoreline.

The Great Lakes shoreline should be cluttered as little as possible in almost all situations, whether the project under consideration is primarily recreational or utilitarian. In container ports, for example, berths laid end-to-end along an existing shoreline needlessly consume shore frontage. Frontage is saved for other utilization or recreational purposes when berths are built in compact clusters. Use of automated, multi-story container storages, instead of the now-customary on-the-ground parking areas, also saves shoreland. Similarly, recreational ports and marinas, if they are designed to eliminate or minimize impact on wetlands and other shore features, will optimize maintenance of the biotic web in which fish, wildlife, and vegetation of the area are interdependent. Man, too, benefits from the "minimum impact" marina, because the conserved shoreline constitutes a resource reserve for additional recreation, conservation, and compatible development uses.

Guidelines provided here are necessarily general. First, little has been done in the past to standardize and systematize site planning and design guidelines for uses on coasts and shorelines. Further research is needed for any full development of sound shore management policies and regulations. Second, Basinwide and even Statewide guidelines are limited by scale considerations. Great Lakes States should develop procedures for encouraging and regulating shoreland planning and design on the local community and individual site scale.

1.2.1 Guideline Definitions

1.2.1.1 Great Lakes Shoreland Corridor

The Great Lakes shoreland corridor is the ribbon of shoreline and related lands that encircles the Great Lakes. It runs between a line two miles offshore and a line one mile inland, or to the inland edge of fragile or uncommon resources contiguous to the one-mile line, whichever distance is greater. Fragile resources include, but may not be limited to, dunes, marshes, streams, and erodible and scenic elements.

1.2.1.2 Corridor Tiers

The three tiers of the Great Lakes shoreland corridor are: Tier 1, Offshore (from two-mile limit to lower edge of wet beach); Tier 2, Shoreline (from lower edge of wet beach to crest of nearest enclosing terrain, or where terrain is flat, to the inland edge of flood-prone shore); and Tier 3, Upper Shoreland (from upper edge of shoreline to inland limit).

1.2.1.3 Priority Resource Zones

Priority resource zones are general divisions of the shoreline corridor. Priorities for management, ranging from preservation to development, can be methodically assigned within these zones. The first priority resource zone encompasses all of Tier 1, Offshore, and Tier 2, Shoreline, as well as those portions of Tier 3, Upper Shoreland, which possess fragile, uncommon, or other significant natural, aesthetic, or cultural resources. The resources of the zone should be managed wisely, predominantly for recreation, wildlife, and amenity. The second priority resource zone encompasses all of the remaining portions of the shoreline corridor and constitutes a resource reserve, which will increase in value as recreational, wildlife management, residential, access, and other demands upon the Great Lakes and their shores continue to grow. The resources of this zone should be managed wisely for all purposes compatible with environmental criteria specific to each landscape or site.

1.2.1.4 Regulatory Districts

Regulatory districts are established by State and local jurisdiction for land use, zoning, or other control purposes.

1.2.1.5 Planning Districts

Planning districts (Figure 12–4) are areawide units where planning may be carried out by authorized agencies.

1.2.1.6 Great Lakes Shoreline Corridor Districts

Great Lakes shoreline corridor districts are environment-defined entities that can serve as either regulatory or advisory planning frameworks. They should include:

(1) Preservation Districts—Areas encompassing significant natural, aesthetic, recreational, and cultural resources in which characteristic values and long-term environmental productivity may be most effectively assured through preservation. Such districts should be kept in the present state or enhanced and restored to the greatest degree possible.

(2) Conservation Districts—Areas encompassing a diversity of natural, aesthetic, recreational, and cultural resources in which

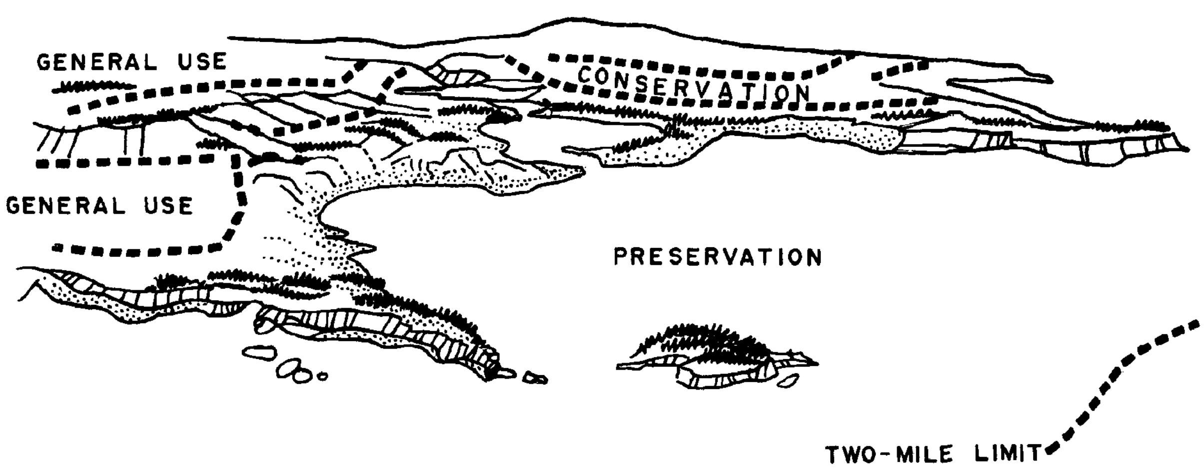

FIGURE 12–4 Planning Districts

characteristic values and long-term environmental productivity may be assured most effectively through combining preservation, enhancement, restoration, and recreation or tourist-oriented development compatible with the existing landscape.

(3) General Use Districts—Areas encompassing resources in which general use development will not significantly affect characteristic value or long-term environmental productivity of the Great Lakes shore and corridor. Landscape preservation, conservation, enhancement, and restoration should also take place if needed.

1.2.2 Use Priorities on a Regional Scale

Shore characteristics vary widely throughout the Great Lakes Basin, reflecting deep differences in geologic formations, climate, and vegetation, and a host of other factors. Man also continues to make a difference. Appendix 19, *Economic and Demographic Studies*, predicts that the population of the Great Lakes Basin will increase by 24 million persons over the present population of 29 million by the year 2020. Moreover, unless controlled, population is likely to continue spreading and threatening reaches of shoreline and the upper shoreland that borders these reaches with indiscriminate modification, increased erosion, and loss of resource value. Much of the anticipated construction along the Great Lakes shores will be second homes, hotel and tourist accomodations, and suburban residences, the owners of which will be attracted by a shore location with minimum nearby development.

State and local land-use policies and regulations should not be restricted to matters relating to the individual site. Such a policy could not prevent the growth of suburban or seasonal development along the shore. Priorities and regulatory devices are needed for the preservation or conservation of entire shore regions, subregions, and individual areas that possess distinctive natural, recreational, or cultural value. At the same time development should be limited to those sectors or regions that can sustain development. Regional diversity should be a Statewide and Basinwide goal.

An important step in achieving regional diversity is the maintenance of a gradient between urban and wilderness areas along the Great Lakes shoreline. It should be assumed that a substantial part of the Basin's population at some future date will not have the means, time, or interest to travel to the truly remote and untouched northern forests and lakes or to undisturbed lakeshore regions that remain beyond the limit of urban spread. Today these areas lie relatively close at hand. If measures are not instituted to maintain the large reaches of natural shorelands that exist today, the travel distances required to reach similar regions in the future either may be too great for the average citizen or may take him outside the Basin.

There is also a need to provide recreation and undisturbed natural areas in the immediate vicinity of urban centers. This can be done both by revitalizing urban waterfront areas and by protecting and enhancing shorelands with recreational reserves and open space buffers on the immediate flanks of cities.

Four urban-to-wild priority status categories may be assigned to shoreland regions:

(1) urban—existing or planned urban areas

(2) urban buffer—areas adjacent to urban areas that may include low-density settlement

(3) natural—areas beyond buffer zones that constitute major portions of shoreline

(4) wild—remote or unmodified areas of significant natural features

The status of any region should help decide regulatory or planning questions. For example, if an area whose priority status is natural qualifies equally as a conservation district and general use district, the area should be designated a conservation district. Regional status should also be reflected in local site regulations. For example, in a natural region minimum setback of buildings from the shoreline should be greater than in an urban buffer region. Variations in setback should also exist among preservation, conservation, and general use district sites.

1.2.3 Basic Shore Types

Ten basic shore types were originally established by the Shore Use and Erosion Work Group to classify the physical characteristics of the Great Lakes shorelands. Principal features expressed by this classification are erodibility, shore height, and shore form composition.

For use guidelines that pertain to the visual landscape as well as to erosion and flooding considerations, additional factors must also be considered. These include degree of slope,

TABLE 12–1 Basic and Modified Shore Types

Guideline Shore Types	Basic Inventory Shore Types	
Artificial Fill Area, Shore	A	Artificial Fill Area
Artificial Fill Area, Island	A	Artificial Fill Area
High Bluff, Slope >30%	HBE HBN	High Bluff Erodible - 30 Ft. or Higher High Bluff Non-Erodible - 30 Ft. or Higher
High Bluff, Slope <30%	HBE HBN	High Bluff Erodible - 30 Ft. or Higher High Bluff Non-Erodible - 30 Ft. or Higher
Low Bluff, Slope >30%	LBE LBN	Low Bluff Erodible - Less than 30 Ft. Low Bluff Non-Erodible - Less than 30 Ft.
Low Bluff, Slope <30%	LBE LBN	Low Bluff Erodible - Less than 30 Ft. Low Bluff Non-Erodible - Less than 30 Ft.
Sand Dune	HD LD	High Dune Sand - 30 Ft. or Higher Low Dune Sand - Less than 30 Ft.
Low Plain	PE PN	Plain Erodible Low Plain Non-Erodible Low
Wetlands	W	Wetlands
Narrow Peninsula or Island		Not Listed

shoreline and upper shoreline configuration, surface texture, horizon type, and vegetative edge. Therefore, for the purposes of guidelines, a modified version of the 10 basic shore types as listed in the left-hand column in Table 12–1 will be used as the general landform classifications. They are inter-referenced with the 10 basic shore types listed on the right.

1.2.4 Unique Shoreland Features

Stream mouths and shore lakes in the Great Lakes shoreland corridor possess significant and distinctive qualities. The stream mouths in many cases are freshwater estuaries possessing mouth bars formed by littoral drift, marshes and sloughs behind the beaches, and low gradient stream reaches that meander toward the Great Lakes. Some shore lakes are drowned river mouths, formed by the great melt of the last ice age and by the deposition of materials on the edge of the Great Lakes. Both stream mouths and shore lakes are significant resources. Careful restrictions should be placed on land use and structural development in their vicinity. Setback and other site controls should be prepared for individual stream mouths and types of shore lakes. A continuous, publicly owned access strip should be secured by State efforts along the edges of each of these resources.

1.2.5 Basic Use-and-Structure Classes

For the purpose of developing a framework that is related to the shoreland's physical and aesthetic fragility, land uses and shore structural types have been grouped into seven classes according to their impact on the shore landscape. The seven use-and-structure classes follow:

Beach Activity (B)
- Low intensity
- High intensity

Green Space (G)
- Agriculture
- Forestry
- Fish and wildlife dependent uses
- Active land and water recreation
- Passive recreation and amenity

Urban/Low Impact (L)
- Low residential
- Small recreation structures
- Small-scale hotel, tourist, vacation facilities
- Low public buildings
- Low office or "clean" industrial buildings
- Low-capacity access roads; paths

Urban/High Impact (H)
- High residential
- Large recreation structures
- Large-scale hotel, tourist, vacation facilities
- High public buildings
- High office or "clean" industrial buildings
- Utility plants
- Factories and warehouses
- Transmission lines: power and fuel
- High-access roads; other transportation
- Spoil disposal

Recreation Harbors (PR)

Commercial Ports (PC)

Shore Structures (S)
- Groins, jetties, causeways, rip-rap, revetments
- Breakwaters, baffles, bulkheads
- Spoil islands, off-shore structures, dredges

1.2.6 Significant Physical Shoreline Characteristics

1.2.6.1 Erodibility

Erosion and flooding of the Great Lakes shorelands constitute major hazards to occupants of many reaches of the Great Lakes shoreline. In some cases remedial measures may be helpful, while in other cases, relocation or land-use regulation may be better alternatives.

Shoreland erosion and flooding characteristics should be considered in regulatory planning and site design. Erosion and flooding problem areas along the Great Lakes shorelands are identified as areas subject to erosion that are generally protected, critical erosion areas that are not protected, noncritical erosion areas that are protected, reaches of shore subject to lake flooding, and reaches of shore that are not subject to erosion or flooding.

Building sites should be carefully regulated within flood-prone or erosion-prone areas. Ideally, no new structures except those for recreational use should be permitted on the 100-year flood plain or in the 30-year erosion zone. (The shore strip may be eroded within 30 years, according to available records.) This should be particularly enforced in critical erosion areas that are not protected and in reaches of shore subject to lake flooding.

1.2.6.2 Surface Texture

The visible grain of the shoreline is important to consider when designing shore uses and activities.

Sand beaches are the most desirable for swimming use, while beaches with pigmented cobbles and other rock materials may be unique scenic and geologic assets. Shore structures should mask beach texture as little as possible. Common beach surfaces are sand, pebbles and cobbles, boulders, and ledge formations.

Bluff texture is important in erosion protection and protection of the scenery. No construction should be allowed on unstable, erosion-prone, or seepage-prone bluffs. No structures should be allowed to diminish the quality of scenic bluffs, or impair dunes and wetlands. The vegetative edge of the shoreline should be left intact as much as possible. Types of vegetative edges are: dune—early; dune—climax; early forest; mixed conifer—deciduous; deciduous; conifer; grassland—shrubland; marsh; shrub swamp; wooded swamp; cultivated; and designed.

1.2.6.3 Configuration

Shoreline configuration refers to the form of the interface between land and water. The manner in which the lake plane meets the land may be concave, straight, convex, or acute. High frequency of such variations may create complex forms, and low frequency may create relatively simple forms.

The degree or angle at which the shoreland slopes down to the lake is equally important, but because slope is included as a basic function of shoreline type, it is not discussed separately here.

The implications of shoreline configuration for planning are important. Closure, which increases proportionately with indented shoreline, provides a better view of the landscape. Planners and review agencies should carefully consider configuration for any proposed project of significant visibility.

1.2.6.4 Upper Shoreland Terrain

The upper shoreland, which constitutes the third tier of the Great Lakes shoreline corridor, is not generally as significant a resource as the offshore and shoreline tiers, but it occupies an important topographic, aesthetic, and ecological position.

Planners and review and regulatory agencies should insure that general use development in the upper shoreland tier, whether it is flat, low or high rolling, or precipitous, does not adversely affect resources on or near the shoreline. Access roads, utility lines, and other infrastructures leading through the upper shoreland towards the shore should be designed with great care.

1.2.6.5 Horizon Types

Horizon refers to the limit of view as seen from the most important observer positions on the shoreline or from principal observer positions on heavily used boating routes. Horizons may be grouped into two general types: those seen on or offshore from Great Lakes shorelines, and those seen from the edges of streams and lakes within the shoreline corridor.

The importance of protecting scenic horizons from new construction's adverse aesthetic impact has obvious implications for planners and review agencies. Care should be exercised in controlling the siting and design of structures with high visibility. In some reaches of shoreline, particularly in preservation districts, stringent aesthetic controls may be required. A careful methodology should be developed to provide planners and review or regulatory agencies with adequate tools to achieve this end.

1.2.7 Basic Guidelines for Site Planning within the First Priority Resource Zone

Site planning considerations that may affect the aesthetic quality of the shoreland within the adjacent to the project site are: degree of intrusion of development into "green" areas; degree of clustering or dispersal of units; setback; mass and silhouette; height; building exterior image (utility, residential, etc.), color, materials, and texture; shore cover; screen plantings; foreground topography (open or masking); access ways; drainage; flood-proneness; erosion-proneness; sanitation; site fixtures (utility poles, signs, etc.).

Concern for each of the above should be expressed in any site plan. Particularly within the first priority resource zone (the shoreline and its adjacent and related areas) consideration should be assured. New procedures should be developed within planning and regulatory frameworks so that plans of any proposed project that may adversely affect the aesthetic qualities or may exacerbate flooding or erosion problems within the first priority resource zone shall first be submitted to a review and control body to ensure satisfactory compliance with existing regulations. Controls regulating siting and design within the first priority resource zone should be reinforced or evolved by the States to meet this need.

1.2.7.1 Degree of Intrusion of Development into Green Areas

Intrusion is very serious in conservation districts because protective mechanisms against spreading development are not as restrictive as in preservation districts. In significant green areas within conservation districts, cluster development may not be a sufficient safeguard against oversettlement. Too many cluster developments can change the image of a rural area to nonrural. To prevent this, permitted-use cluster developments ought to be grouped in order to conserve larger areas of intact green space within the district. Compensation and other encouragements to this end ought to be researched.

1.2.7.2 Degree of Clustering or Dispersal of Units

Units of any given development in any location within the Great Lakes shoreland corridor should be clustered as much as possible, conserving open space and shore, which will benefit both the development's occupants and the public at large. Interior open spaces of cluster developments should meet minimum dimensions, which should be researched and set. Cluster development open space should be linked with public open space systems wherever possible.

1.2.7.3 Setback and Height

Because of the dearth of criteria for the establishment of building setback and height controls, effective controls are generally absent in many shoreline areas of the Great Lakes. Research into the aesthetic relationships between man-made forms and the natural environment in the Great Lakes shoreline corridor would undoubtedly help define supportable and effective control standards.

The following guidelines could be used as standards if one accepts their chief purposes, which are to preserve the existing appearance of the Great Lakes shoreline, and to minimize environmental impact on natural values as well as on the views seen from public areas:

(1) Setback and height controls should be more restrictive in conservation districts than in general use districts.

(2) For more shallow bluff slopes behind recreation beaches, the setback of buildings from the bluff crest should be increased and the height of buildings should be decreased. Setback is a function of visibility to the beach user. Other important observer positions should also be considered.

(3) The greater the indentation of a shoreline, the greater the consideration should be of potential visual impact to the sides of the proposed development.

(4) The steeper the slope of a secondary bluff, the greater the restrictions on construction on that slope face should be. Local geological and soil surveys should be referred to for restrictive guidelines.

(5) The sparser the vegetation on any steep slope within view of the shore, the greater the restrictions on use of that slope face should be.

(6) Tall structures should be permitted to rise into partial but not complete view near the shoreline. Screen vegetation, bluff steepness, and principal observer positions are three variables in this consideration. If a principal observer position lies on an offshore island, buildings behind the crest of a low bluff should be set much further back than if principal observer positions existed on the mainland beach alone.

1.2.7.4 Mass and Silhouette

Wherever situated within view of a scenic resource, building mass should be as inconspicuous as possible. Mass should be articulated into component units wherever feasible and integrated into the landscape. Silhouette and roof forms should be variegated, rather than box-like, for effective harmonization with the surrounding landscape. Thin building profiles should face the shore. Thin towers are preferable to slabs and bulky structures.

1.2.7.5 Building Exterior Image: Color, Materials, and Texture

Utilities and manufacturing plants need not appear strictly utilitarian. Natural earth materials and colors and building forms that are typically found in traditional coastal architecture should be employed wherever possible. In localities that have not developed attractive coastal architectural forms, forms typical of other coastal regions of the United States and Canada should be used. Contemporary materials, colors, and building forms can be used wherever innovative architecture will harmonize with the surrounding environment.

1.2.7.6 Shore Cover and Screen Plantings

Living materials can soften and harmonize structures that are incongruous with the shoreline landscape.

1.2.7.7 Foreground Topography

Earth berms, mounds, and other topographic modifications can also be used in conjunction with vegetation to disguise or blend an awkward structure into the environment.

1.2.7.8 Access Ways

Roads, rail lines, aircraft landing strips (other than seaplane landings), other transportation facilities, and parking and storage depots should be located as far from the shore as possible. General arterial alignment should be parallel to and distant from the shore. Small feeder roads and footpaths should extend from principal routes to the shore zone. Feeder roads, particularly those leading to marinas, beaches, and other recreation, tourist, and cultural sites, should be designed with a strong emphasis on aesthetics. They should be winding rather than straight with abundant roadside plantings and scenic vistas, glimpsed through controlled thinning and clearance that permit the traveller to see the shore and lake as he approaches.

1.2.7.9 Flood-Proneness

No construction should be permitted in the floodways of streams draining the shoreline corridor. Use of the 100-year flood plain of the streams and the Great Lakes should be restricted to recreation, agriculture, conservation and other uses which do not constitute a hazard to the public safety, health, and welfare.

1.2.7.10 Erosion-Proneness

No construction should be permitted in areas susceptible to hazardous erosion in the next 100 years or within an erosion-prone area of a shorter designated period, to be determined by the States. Such areas can be delineated on the basis of accepted projections.

1.2.7.11 Sanitation

Site development should fully conform to State sanitary codes, which should be upgraded to adequately forestall ground, stream, and lake pollution due to improper functioning of sewage collection, disposal, or treatment systems.

1.2.7.12 Site Fixtures

Billboards, utility poles, and other fixtures detract from the value of any site, especially one offering a quality environment like the Great Lakes shoreline. Specific landscape analysis and proper site planning for proposed development should be undertaken by developers consulting with planning and review agencies to minimize or eliminate poor quality fixtures.

1.2.8 Compatibility Between Shore Type and Use-and-Structure Classes

Table 12–2 summarizes the compatibility between the various shore types and use and structure classes.

1.2.9 Site Criteria by Shore Type

The following are generalized guidelines. Actual site planning requires specific site data and expert landscape analysis.

1.2.9.1 Shore Type 1, Artificial Fill

(1) Shoreline configuration and horizons—should indent new shorelines to heighten tier recreational and aesthetic potential, take advantage of shore protection work or other reconstruction to provide shore indentations along existing shorelines where feasible, and develop urban area plans for optimizing views of and from focal points.

(2) Shore edge—should provide public embankment and recreation reserve along new shorelines to the minimum depth required for satisfactory noise and air quality and should buffer adjacent road or urban edge. At present, the minimum distance is 300 feet. Shore protection work and other reconstruction projects along existing shores should be utilized to restore public access and recreation facilities.

(3) Setback and height control—should establish ground floor minimum building setback for properties facing public or shore areas, and establish maximum height zoning controls leading from low to high away from shore. Spacing requirements between tall buildings should be established along the shoreline to:

(a) prevent concentration

(b) increase compactness, according to landscape and horizon requirements for area display

(c) provide a multiple-purpose shore strip for recreation and other public shore-related activities in ports and industrial areas, where feasible

(4) Vegetative edge—rows of trees suitable to urban shorelands should be planted along the edge of urban high impact and other shore use and activity areas, including industrial and port zones. Select species of ground cover, shrubs, and trees that can be planted together among shore protection structures, should be

TABLE 12–2 Matrix Check for Compatibility Between Shore Type and Use-and-Structure Classes[a]

Shore Type	Recommended Shoreline Priority Districts[b]	Use-and-Structure Classes						
		Beach Activity	Green Space	Urban/Low Impact	Urban/High Impact	Recreation Harbors	Commercial Ports	Shore Structures
Type 1	Conservation	GC L	GC L	GC SS HH L	GI	GC L	GI	GC L
Artificial fill, Shore	General Use	GC L	GC L	GC S L	GC S H L	GC L	GC	GC L
Type 2	Conservation	GC[c]	GC	LC SS HH L	LC	GC	LC	GC
Artificial fill, Island	General Use	GC[c]	GC	GC S H L	GC	GC	GC	GC
Type 3	Preservation	GC	GC	GI	GI	GI	GI	LC LL
High Bluff, Slope >30%	Conservation	GC	GC	LC SS HH	GI	LC	GI	LC LL
Type 4	Preservation	GC	GC	GI	GI	LC LL	GI	LC LL
High Bluff, Slope <30%	Conservation	GC	GC	LC SS HH	GI	GC L	GI	LC LL
Type 5	Preservation	GC	GC	GI	GI	LC LL	GI	LC LL
Low Bluff, Slope >30%	Conservation	GC	GC	LC SS HH	GI	GC L	GI	LC LL
Type 6	Preservation	GC	GC	GI	GI	LC LL	GI	LC LL
Low Bluff Slope <30%	Conservation	GC L	GC	LC S H	LC	GC L	GI	LC LL
Type 7	Preservation	GC	GC	GI	GI	GI	GI	GI
Sand Dunes	Conservation	GC	GC	GC[d] GI (other)	GI	GC[e]	GI	LC
Type 8	Preservation	GC	GC	GI	GI	GC LL	GI	LL
Low Plain	Conservation	GC L	GC	GC S H	GI	GC	GI	LL
	General Use	GC LL	GC	GC S H	GC SS H	GC		L
Type 9	Preservation		GC	GI	GI	GI	GI	GI
Wetlands	Conservation		GC	GI	GI	GI (within) (adjacent)	GI	GI
Type 10	Preservation	GC	GC	GI	GI	GC	GI	GI
Narrow Peninsula or Island	Conservation	GC	GC	GC	GI	GC	GC	GI

NOTE:
- GC general compatibility
- LC limited compatibility
- GI general incompatibility
- S/SS setback beneficial: moderate/pronounced (refers to setback from bluff crest or erosion/flood zones, whichever applicable)
- H/HH height and mass control beneficial: moderate/pronounced
- L landscape enhancement or screening beneficial

[a]Refer to glossary for definitions.

[b]Omission of a Priority District in this column indicates general unsuitability of shore type.

[c]Where littoral drift is favorable.

[d]Dune compatible recreation, conditional upon dune conservation practices.

[e]If dunes are not altered.

used both for aesthetic and shore stablilization objectives. Marshes should be reestablished on degraded wetlands, and filling or diking of existing wetlands should be prevented. Spoil islands should be created under safeguards to avoid detriment to the environment.

1.2.9.2 Shore Type 2, Artificial Fill, Island

(1) Shoreline configuration and horizons—should have irregular perimeter to naturalize island form and provide lee for recreation harbors and sand beaches.

(2) Shore edge—tops of dikes should be surfaced to provide a public embankment.

(3) Setback and height control—should be provided where suitable. Should arrange building clusters of varying heights to accentuate island form. On islands for park and recreation purposes, major buildings should be confined to a single focus and where marsh is to be established, structures should be at a low visibility.

(4) Vegetative edge—vegetation should be provided where suitable by importing soil and adaptable trees for island edge to enhance island silhouette and to limit leaching.

1.2.9.3 Shore Type 3, High Bluff, Slope Greater than 30 Percent

(1) Shoreline configuration and horizons—the greater the degree of indentation, the stricter siting controls should be in the shoreline zone. Greater restrictions should be placed on those shores which are viewed as horizons from opposite shores nearby.

(2) Shore edge—on highly indented shorelines, emergence of structures above existing treetops on lakeside of mainland base line should be prevented.

(3) Slope—on both erodible and nonerodible slopes development should be avoided on primary bluff faces and on nearby secondary bluff faces with sparse vegetation. Development on nonerodible secondary slopes exceeding 30 percent should be restricted. Development should be avoided on erodible secondary bluff faces where slope exceeds 12 percent, or on less steep slopes where advised by soil survey.

(4) Setback and height control—construction within the 30-year erosion zone or a greater period as determined by recession rate or legislation should be restricted. Setback should be established behind bluff crest where tall structures will be in only partial view from mid-distance or bluff crest observer positions. A 200-foot normal setback should be employed.

(5) Vegetative edge—shore strip regulations should be maintained. Tree density on bluff crest and shrub and ground cover density on slopes should be increased for adequate screening of uses and activities.

1.2.9.4 Shore Type 4, High Bluff, Slope Less than 30 Percent

(1) Shoreline configuration and horizons—the greater the indentation, the stricter siting controls should be in the shoreline zone. Greater restrictions should also be placed on those shores that are seen from nearby opposite shores.

(2) Shore edge—on highly indented shorelines, emergence of structures above existing treetops on lakeside of mainland base line should be prevented.

(3) Slope—on both erodible and nonerodible slopes development should be avoided on primary bluff faces and on nearby secondary bluff faces with sparse vegetation. Development on nonerodible secondary slopes exceeding 30 percent should be restricted. On erodible secondary bluff faces, development should be avoided where slope exceeds 12 percent or on less steep slopes where advised by soil survey.

(4) Setback and height control—construction should be restricted within the 30-year erosion zone, and a 200-foot normal setback should be established behind bluff crest where tall structures will be in only partial view from mid-distance or bluff crest observer positions.

(5) Vegetative edge—shore strip regulations should be maintained. Tree density on bluff crest and shrub and ground cover density on slopes should be increased for adequate screening of uses and activities.

1.2.9.5 Shore Type 5, Low Bluff, Slope Greater than 30 Percent

(1) Shoreline configuration and horizons—the greater the indentation, the more strict the siting controls should be in the shoreline zone. Greater restrictions should also be placed on those shores which are viewed as horizons from nearby opposite shores.

(2) Shore edge—on highly indented shorelines, emergence of structures above existing treetops on lakeside of mainland base line should be prevented.

(3) Slope—on both erodible and nonerodible slopes, development should be avoided on primary bluff faces and on nearby secondary bluff faces with sparse vegetation. Development should be restricted on nonerodible secondary slopes exceeding 30 percent. On erodible secondary bluff faces, development should be avoided where slope exceeds 12 percent, or on less steep slopes where advised by soil survey.

(4) Setback and height control—construction should be restricted within the 30-year erosion zone. A 300-foot normal scenic setback should be established behind bluff crest where tall structures will be in only partial view from near shore or bluff crest observer positions.

(5) Vegetative edge—shore strip regulations should be maintained. Tree density on bluff crest and shrub and ground cover density on slopes should be increased for adequate screening of uses and activities.

1.2.9.6 Shore Type 6, Low Bluff, Slope Less than 30 Percent

(1) Shoreline configuration and hori-

zons—the greater the indentation, the stricter the siting controls should be in the shoreline zone. Greater restrictions should also be placed on those shores which are seen from opposite shores nearby.

(2) Shore edge—on highly indented shorelines, emergence of high structures above existing treetops on the lakeside of mainland base line should be prevented.

(3) Slope—on both erodible and nonerodible slopes, development should be avoided on primary bluff faces and on nearby secondary bluff faces with sparse vegetation. Development on nonerodible secondary slopes exceeding 30 percent should be restricted. On erodible secondary bluff faces, development should be avoided where slope exceeds 12 percent, or on less steep slopes where advised by soil survey.

(4) Setback and height control—construction should be restricted within the 100-year flood-prone and 30-year erosion zones. A 400-foot normal scenic setback should be established behind bluff crest where tall structures will be in only partial view from mid-distance or bluff crest observer positions.

(5) Vegetative edge—shore strip regulations should be maintained. Tree density on bluff crest and shrub and ground cover density on slopes should be increased for adequate screening of uses and activities.

1.2.9.7 Shore Type 7, Sand Dunes

(1) Crest configuration and slopes—no uses and structures other than for dune-compatible recreation should be permitted except on back dunes where environmental impact may be negligible. Dune-compatible recreation structures should be sited on crests of secondary or back dunes to minimize dune slope destabilization. Fore dunes should be avoided. All site design should minimize disturbance of dune stability and appearance.

(2) Paths and access—paths should be routed along troughs to avoid slope disturbance. Boardwalks and steps should be constructed across stable dunes at limited points. Dune buggies, trail bikes, and other vehicles should be restricted to beaches of adequate dimensions under limited access restrictions. No access to the dunes proper should be allowed. Vehicular use should be suspended if beaches erode. All vehicular access should cross stable ground at extremities of dune areas or through blowouts within marked rights-of-way.

(3) Vegetation and stabilization—dune stabilizing species should be reestablished wherever stability has been impaired. Dunes in blowouts and mined areas should be rehabilitated where feasible. Private dune properties that are subject to recurring erosion damage as a result of improper siting of structures should be publicly acquired, and owners should be relocated at a suitable shoreland area.

1.2.9.8 Shore Type 8, Low Plains

(1) Shoreline configuration and horizons—generally, low plain shorelines possess a straight or slightly curved edge. In general-use districts, recreation harbor and urban shore uses can be planned and designed to strengthen nodal character. Guidelines are similar to those for Shore Type 1.

(2) Shore edge—in general-use districts, guidelines are like those for Shore Type 1.

(3) Setback, height control, and vegetative edge—construction should be restricted within the 100-year flood-prone and 30-year erosion zones. Building setbacks compatible with regulatory district character should be established. Building setbacks should coincide with shore strip depth requirements ranging from 50 to 300 feet. The role of shore cover is discussed in Subsection 1.2.10. Height regulation should be similar to that described for Shore Type 1.

1.2.9.9 Shore Type 9, Wetlands

(1) Shoreline configuration and horizons—wetlands viability should be permitted except on ground sites permanently higher than water table fluctuations which are accessible with negligible disturbance of the environment.

(2) Shoreline configuration—wetlands should not be diked or filled. Wetland-bordered lakes and ponds should be beneficially managed for wildfowl without permanent wetland inundation, and natural perimeters of wetlands should be left in their natural state to maintain ecological viability and aesthetic qualities.

(3) Paths and access—paths should be located on higher elevations while boardwalks should be constructed across wet areas.

(4) Structures—boat piers and small marinas in the interior or wetland precincts

should be constructed on platforms and pilings over open water. Large marinas and boat storages should be sited outside wetlands. Design should follow typical regional building forms and should employ wood, stone, and similarly textured materials to maximize integration of structures into wildness of wetland landscape. Structural silhouettes should be low.

1.2.9.10 Shore Type 10, Narrow Peninsula or Island

(1) Configuration and horizons—because of the proximity a peninsula spine has to a lake, all its land area possesses scenic sensitivity. View outward to lake horizons should be maintained by preventing "walls" of building construction.

(2) Shore edge—a large number of access points to highly attractive shoreline should be provided. Overconcentration of facilities at nodes with limited carrying capacity should be prevented (i.e., limit the impact on the facilities and the environment).

(3) Slope—housing should be accommodated on slopes, where steepness and soil erodibility allow.

(4) Setback, height control, and vegetative edge—construction should be restricted on crests or sharp ridges. Construction of buildings which exceed average tree height should be avoided. Setback should be 100 feet from shore and the vegetation should be reinforced.

1.2.10 The Role of Shore Cover

Tree cutting and removal of other vegetative cover along the shores of the corridor should be regulated "to protect scenic beauty, control erosion and reduce effluent and nutrient flow from the shoreland" (Wisconsin statutory regulation).

Many densely rooted and densely spaced plants can contribute to shore stabilization, particularly in noncritical erosion areas.

Native, established vegetative cover should be maintained where it exists, and additional vegetation should be planted to increase density if needed for shore stabilization or scenic enhancement.

New cover should be established on exposed, erodible shorelands in conjunction with structural protection measures, or alone.

Plants considered important for shore stabilization along the Great Lakes are listed in Table 12-3.

TABLE 12-3 Plants Important for Great Lakes Shore Stabilization

Native Species
Pioneer Zone
Ammophila breviligulata (beach grass)
Cakile endentula (sea rocket)
Calamovilfa longifolia (dune grass)
Ammophila breviligulata (sand reedgrass
Scrub Zone
Prunus serotina (black cherry)
Salix syrticola (dune willow)
Corrus stolonifera (red osier dogwood)
Juniperus horizontalis (creeping juniper)
Forest Zone
Arctostaphylus eva ursi (madrona)
Populus deltoides (cottonwood)
Populus tremuloides (quaking aspen)
Exotic Species
Pioneer Zone
Agropyron dasystachyum (hairy wild wheat)
Agropyron species (wild wheats)
Artemisia species (wormwood)
Elymus arenarius (sea lymegrass)
Pteridium species (brachen fern)
Scrub Zone
Cystisus species (brooms)
Eleagnus sagentata (common name not identified)
Erica species (heaths)
Populus species (aspens and poplars)
Pyrecantha species (firethorns)
Rosa species (roses)
Forest Zone
Prunus virginiana (choke cherry)

Source: Shore Protection, Planning and Design, U.S. Army Coastal Engineering Research Center, Corps of Engineers, Technical Report No. 4, Third Edition, 1966, Part 2, Chap. 5, Table 5-15.

The manner in which shore cover is maintained, removed, restored, and reinforced is also aesthetically important. Thinning out of trees is preferable to clear-cutting, which with severe thinning should not be allowed on highly erodible soils and slopes.

Shore cover regulation should reflect both the vegetative type and the resource priority status of the shoreline. A minimum depth of 100 feet in conifer-dominant regions, and 200 feet in deciduous-dominant regions, should be maintained in general use districts to ensure sufficient screening of structures and accessories. Greater widths may be necessary in stands of old, tall trees which are prone to wind topping. In conservation districts the minimum depth dimensions should be 150 to

300 feet. In "hardship" cases, property owners could be excepted on the condition that a State or locally approved landscape plan first be accepted. This recommendation requires further research.

Where done, clear-cutting should not extend more than 30 percent of the length of the shore strip of any property frontage (Wisconsin statutory regulation). Cutting that is more extensive than the 30 percent limit should be allowed only in accord with an approved cutting plan that ensures suitable screening of structures and accessories (Wisconsin statutory regulation).

Natural shrubbery should be preserved where practicable. If removed it should be replaced with other vegetation that is equally effective in preventing erosion and preserving natural beauty (Wisconsin statutory regulation).

Tree seedlings and shrubs should be made available to shoreland owners at a nominal cost to encourage restoration or reinforcement of shore cover.

The planting of new trees and shrubs as screens should utilize species, planting patterns, massing, and plant heights that are compatible with the structural images they are intended to disguise.

1.2.11 Artificial Islands

The development of new islands in the waters of the Great Lakes can have far reaching environmental impact. Benefits may include a diversification of horizon landscape and the development of new recreation grounds, new harbors of refuge, new wildfowl refuge areas, and new sites for other approved, lake-compatible public uses. Possible detriment is also well recognized in the form of possible increased pollution from fill leachates and possible interference with littoral drift and natural beach replenishment.

At several locations along the Great Lakes shores, dredging spoil has been deposited at offshore sites to form new islands. In most cases the islands have been little used. Rectangular or polygonal in shape, they have not been specifically designed for recreational, aesthetic, wildfowl management, or shore protection objectives.

New sites and new environmentally safe disposal methods for construction debris, incineration slag, and other solid wastes are being sought on land and in the Lakes. The effectiveness, durability, and re-use potential of islands made of dredging spoil, construction debris, and other materials, and their effect on water quality must be investigated. Research is also needed on prevention of harmful leaching and on fill-vegetation relationships.

Because they are shallow, shoals are potential fill-island sites, but they are also valuable feeding and spawning grounds for fisheries in the Great Lakes, and as such, constitute an important link in the lake food web.

Shoals with little biotic value may serve as ideal sites for offshore spoil islands, which would provide new feeding surfaces for fisheries and feeding and nesting areas for wildfowl.

Narrow islands designed on low value shoals and other shallow offshore sites parallel to the shore may act as breakwaters to protect erodible shoreline from wave erosion. Linear islands may achieve aesthetic, recreational, and other environmental objectives best if the following guidelines are used:

(1) Create "natural" island contours and elevations.

(2) Shape islands paralleling shores in a linear form to act as breakwaters. Take advantage of the linear form to develop initial areas at an early stage.

(3) Select shoal line or suitable benthic contours where littoral drift can be expected to nourish existing beaches while ceasing or lessening erosion on other beaches and shores.

(4) Plan chains of linear islands offshore from high-erosion shorelines, if possible.

(5) If feasible, plan islands to dissipate wave energy in order to eliminate need for structural protection on mainland.

(6) Provide recreational harbors as part of island design.

(7) Ensure environmental protection by utilizing research findings on leachings, permeability barriers, suitability of fill materials, and biotic and physical inter-relationships.

1.3 The Physical Setting

The second part of the planning framework for the Great Lakes shorelands is an inventory of the existing natural, cultural, and physical characteristics of the shorelands, to which the guidelines apply. Many significant characteristics of the Great Lakes shorelands have been identified in the *Great Lakes Basin Framework Study* appendixes or in other existing sources:

(1) shoreland use and ownership (this appendix)

(2) shore type (this appendix)
(3) significant environmental areas (this appendix) including significant fish and wildlife habitat, natural and scenic shorelands, and critical bird nesting and migration areas (identification of shorelands having significant fauna and flora characteristics has not been accomplished, but it is needed and worthy of future research)
(4) shore vegetation (requires further research and inventory work)
(5) water quality (Appendix 7, *Water Quality*)
(6) water depths (navigation charts published by U.S. Lake Survey Center, NOAA)
(7) economic projections (Appendix 19, *Economic and Demographic Studies*)
(8) current lake patterns (Appendix 4, *Limnology of Lakes and Embayments*)

1.4 Legal Frameworks

1.4.1 Legal Techniques

Various legal mechanisms can be used to influence people in their use of the shorelands: public acquisition, historic or scenic easements, public policy inducements, tax structures, regulatory controls, and compulsory takings. Each of these mechanisms to increase public control of the land has its own capabilities and limitations.

1.4.1.1 Public Acquisition

Acquisition agreements, in which ownership or certain rights are obtained for an authorized public purpose by donation or by purchase at mutually acceptable prices, can be made between the government and an individual or between private individuals. Acqusition in fee simple, which confers complete ownership and usage rights, is the most absolute means of control over development and use of the coastal zone. It is also the most costly.

In lieu of outright ownership, government can acquire lesser rights to use private property or to limit its use by the owner. Through acquisition of scenic or historic easements, restrictions, or development rights, the cost of acquisition can be reduced while the land is left on the tax rolls in private ownership.

A mechanism that warrants more consideration is the public purchase of private property, which is then resold or leased to private individuals under certain deed or lease restrictions necessary to protect natural shoreland resources.

Property needed for the future can be acquired with the little-used but effective techniques of fee simple combined with leaseback, discount bonds, and the purchase of options. Land acquired in fee simple reserves for the owner a life estate in the improvements. Discount bonds are a means of deferring the payment of both interest and principal to a later date when the benefits of land holding are realized. The third technique, the purchase of an option to acquire property in fee simple for a specified price at a future date, is useful when a future need for additional public beaches is foreseen. It may be much less expensive, even when interest is considered, to purchase this option now than to purchase the property later in a highly developed state. Until the property is needed for public purposes it can be used for residential or other private purposes.

1.4.1.2 Public Policy Inducements

Shoreland management objectives can often be served by public policies, such as taxation, that indirectly influence the way people use shore property. Almost all coastal communities employ property taxes to provide funds for their services, but taxes can be levied differently. When property taxes are tied to the "best use" of land under a zoning system, property owners are induced to develop their land up to this level or sell to someone who will. If property tax levels are tied to actual use, there is less pressure to develop the land. To encourage special uses and actions critical to a master plan, preferential tax levels can be levied and taxes can be deferred or waived. Such methods are employed to preserve open space or encourage conservation measures, but they may also encourage speculative land holding.

1.4.1.3 Regulatory Controls

Shoreland management can often be satisfied by direct use control of both private and public property, using governmental police power. The appropriate legislative body allows this particular exercise of authority when it finds the need articulated in legally sufficient detail. Important regulatory controls include zoning, subdivision regulations, building codes, platting requirements, deed restrictions, permits, and ordinances, all of which can be applied with considerable flexibility.

1.4.1.4 Compulsory Taking

Of all the management techniques, compulsory taking is the strongest imposition of public power over individuals. Its two forms are condemnation and inverse condemnation.

When ownership or lesser property rights required for an authorized public purpose cannot be acquired at a reasonable negotiated price, government may exercise its right of eminent domain and acquire the property by condemnation, paying what it unilaterally judges to be fair compensation. The landowner has the right to appeal the decision in the courts.

However, when control is so severe that the owner is deprived of substantial use of his property, the owner may appeal and courts may require the government to compensate the owner for his loss. The precise point at which the exercise of police powers constitutes a taking is a key legal determination which varies considerably with specific circumstances. The manner in which it is determined is beyond the scope of these guidelines.

1.5 Institutional Arrangements

1.5.1 Introduction

Shoreland planning and management programs in the Great Lakes are operated mostly on an independent and piecemeal basis. To be effective, coastal zone planning must be comprehensive and integrated to include all uses and conflicting demands upon the waters and contiguous lands of the zone. It must also take into consideration both short- and long-term requirements for the different areas, while transcending existing political subdivisions. Wisdom and insight are needed to minimize problems and conflicts in the coastal zone.

Coastal planning requires a judicious balance between multi-purpose development, conservation, and preservation, based on an inventory of the shoreland and studies of institutional structures necessary to implement effective shore zone management.

Existing Federal and State shoreland planning and management mechanisms are discussed in Appendix F20, *Federal Laws, Policies, and Institutional Arrangements*, and Appendix S20, *State Laws, Policies, and Institutional Arrangements.* Some of the more pertinent mechanisms are also briefly referenced in Sections 3 and 4 of this appendix.

1.5.2 State Involvement in Shoreland Management

Most State management instruments are effective below the line of ordinary high water, a line notoriously difficult to fix without a uniform datum. Most resources affecting the appearance and use of the shorelands, including many of the most productive marsh and swamp associations, are above the line of ordinary high water.

States should recognize the natural attributes of the shorelands in the interest of all residents of each State and protect and enhance the quality of the natural and manmade environment in the long-term best interest of all State residents. The Federal government should recognize the natural attributes of the Great Lakes shorelands in the interest of all residents of the nation. The difficulty comes when objectives perceived nationally do not agree with the view of an individual State, or when there are sharp differences of opinion among Federal agencies as to the true nature of national interest in specific places.

The Great Lakes Basin Commission has an unusual opportunity to clarify the national interest, mediate differences between national values and State views, and to encourage consistent State views and policies.

Adequate authority to manage Great Lakes shoreland resources usually exists collectively among agencies of the several State governments, if the authorities are effectively coordinated. There are exceptions, however.

Line agencies do not have specific mandates to include amenity and aesthetic concerns when implementing resource use projects. Jetties, for example, are designed for their effectiveness, not their appearance. The possibility of working with offshore islands illustrates the importance of good design for all offshore structures. Problems also arise when locating and designing utility facilities serving shoreland developments. Highways, powerlines, and pipelines for water, sewage, and fuel cross the first and second priority resource zones without consideration of their impact on the resources or on the natural scene.

Authority to consider specifically the impact of proposed projects on the shoreland systems should be granted to a single planning agency or be included in the mandate to the individual State agencies. Without authority meaningful coordination of State activities is nearly impossible.

Concerns for shoreland values are now shared with local political subdivisions by States and their agencies. Final decisions on modifying outstanding scenic areas in the region often are in the hands of municipal governments.

Sub-State regional mechanisms to arbitrate differences between local and State oriented programs are ineffective, but there are regional agencies spurred on by Federal grant-in-aid policies. These regional agencies have an area of jurisdiction which includes nearly all Great Lakes shoreland. The agencies are governed by boards of directors composed of a majority of elected officials. Regional planning agencies can be a central force in the preparation of State agency programs and investments, which is ideal for relating specific action proposals to the perceived values of local people and the larger public. Mechanisms serving sub-State regions by coordinating local needs with State budgets could be instrumental in maintaining shoreland management programs.

1.5.2.1 Policies and Criteria

The designation of first and second priority resource zones and preservation and conservation units in the first priority zone is a first step toward optimizing values perceived by the State.

(1) Preservation units—Areas meeting the criteria for preservation units are elements essential to maintaining and improving the current endowment of shoreland resources found in the Region. These lands should be kept in their present condition as much as possible.

Procedure—Massachusetts and Connecticut accurately survey lands constituting preservation units. The survey is recorded in the county records and attached to the deed of each parcel of property within the units. The State declares coastal preservation units and notifies all landowners in each unit. A prescribed period of time is allowed for owners to file for compensation if they feel deprived of value. If it is judged that taking without due process has occurred, the State has the option to acquire fee or partial title to the property. At the expiration of the time period, lands on which no appeal has been filed are governed by the declaration of no use.

(2) Conservation units—These areas represent the bulk of a region's important environmental resources. Measures to conserve them must vary according to the type and intensity of development within or near them. Run-off from subdivisions built on the coastal uplands, for example, may choke creeks and bays with sediments and nutrient-algal blooms. With these relationships in mind, proposals for regulations in the region can be objectively evaluated and decisions taken.

Procedure—Maine and Vermont pioneered resource management in designated conservation units. Essentially, the States reserve the right to review all modifications proposed within conservation unit zones. The site review process extends to public as well as private proposals. Rigorous criteria are necessary to guide decisions. The issues include:

(a) adoption of standards that establish the right of public access to beaches

(b) minimum building codes for all structures and provision for disposal of sanitary waste within the unit

(c) design criteria such as those adopted by the New York Public Utility Commission for transmission line crossings of highways, for transportation and utility corridors when they cross the first priority resource zones

(d) requirements for urban waterfronts

(e) maintenance of historic quality

(f) treatment of inlets and erosion control structures such as groins and jetties.

The principal at issue is whether coastal environmental considerations are to be part of the decision-making process. The designated State management agency could require representation on bodies that now decide these issues, or it could provide for joint review by furnishing staff assistance to regional clearinghouses and Section 204 review agencies.

The availability of zoning criteria and strategic procedures to review proposals as a condition for funding (either from Federal grants-in-aid or as an item in the State's capital budget) would encourage maximum use of easements. Analysis of highway corridor intersections that border first priority resource zones might pinpoint good opportunities for scenic or conservation easements as pioneered by the Wisconsin State Highway Department. The closer land parcels are to a city, the more nearly the price of an easement equals full fee simple price. In rural areas, the price may be one-half or less than acquisition of full rights to the property.

(3) General purpose units—Remaining lands can be considered suitable for industrial, commercial, and residential development. Shoreland general purpose units, especially within the first priority resource zone, should be subject to regulation that will optimize environmental quality for all shorelands in the Region. Development subzones within the first priority resource zone and the lands of the second priority resource zone are subject to one of three levels of regulations:

(a) State specified minimum building codes enacted by local government

(b) State review requirements that are the same as exercised in conservation units

(c) local minimum standards set without State involvement

Procedure—The extent of State investment (for highways, water lines, and sewage collection and treatment) and the size of the development determine whether the subzone will be regulated by State minimum building and development codes. Large industrial plants, commercial centers, large-scale subdivisions, and highway interchanges are examples of developments that could endanger the values that motivate State action in the preservation and conservation units. If local governments are willing to adopt and enforce building and development codes to meet the State's needs, then development of these lands and facilities can proceed without further State action. In the absence of local ordinances, the authorization of developments would be assumed by the State. Some State supervision is already exerted on large-scale developments in that agencies with jurisdiction over public health and pollution control must approve methods of waste disposal and water supply sources.

Sub-zones where State review authority is the same as for conservation units could be those waterfronts now committed to development. Design criteria for new development or redevelopment should emphasize the aesthetic impact. The design and use of such development, of course, directly affects the quality of the water and of recreation experiences.

In the remaining general purpose units, small-scale development is subject only to the conditions levied by local jurisdiction.

1.5.2.2 Incentives and Disincentives

Since the publication "Open Space for Urban America" appeared in 1968, several States have encouraged the maintenance of open space through differential taxation—particularly with respect to farms. California, Nevada, and Maryland, among others, froze farmland assessments by considering the real property value as farmland rather than potential subdivision value when calculating property taxes. If the owner chooses to convert his farm to other purposes, he must pay in some cases the difference between the farm level tax and the subdivision level tax plus interest for the preceding 10 years.

As with easements, the differential tax works well in rural areas where development pressures have not driven up real estate values rapidly. In prime suburban locations, however, speculators can hide behind a farm declaration because the penalty of additional taxes plus interest is far less than the rewards of selling, which can be $13,000 per acre.

1.5.3 Conclusions

The designation of first and second priority resource zones and the further identification of preservation, conservation, and general purposes units are initial steps in tailoring specific criteria and guidelines for preserving, enhancing, and restoring shoreland resources. Criteria used for the delineations are compatible with the objective of bringing man's use of his environment in line with existing natural systems.

Controls range from total State control over submerged lands and the water column above them to areas where decision-making is entirely in the hands of local government. The range in controls approximates the distribution of costs and benefits of shoreland resource management. Where the people of a State benefit, State government pays the costs and makes the decisions. Where benefits are largely confined to the residents of a single jurisdiction, the local residents pay the costs and make the decisions.

1.6 Pilot Study

The long-range success of shoreland management depends largely on State, regional, and local government cooperation and motivation for protecting the shoreland areas. With this in view, a pilot study, undertaken in Michigan's Grand Traverse Bay region by the Michigan Water Resources Commission and the University of Michigan Sea Grant Program, is determining the feasibility of a comprehensive regional approach to shoreland planning and management through local initiative and action. This regional approach is being developed in the context of the Michigan Shoreland Protection and Management Act of 1970 and the planning framework previously presented in this section. The Water Resources Commission and the Sea Grant Program, acting in a technical advisory capacity, provide local groups and agencies background data and information concerning a shoreland plan for the bay. This pilot program, a starting point for viewing the remainder of Michigan's Great Lakes shorelands, should also provide valuable information on the problems and feasibility of a comprehensive regional approach to Great Lakes shoreland planning and management in general.

Section 2

COASTAL PROCESSES AND SHORE PROTECTION

2.1 Introduction

Great Lakes shores are a dynamic system of water and earth in a state of constant motion. The gross, short-term processes are known and fairly well understood by scientists and engineers, who are able to formulate effective shore protection methods that have been applied around the world with encouraging results.

2.2 The Great Lakes Coastal Zone

The Coastal Zone Management Act of 1972 defines the coastal zone as "the coastal waters (including the land therein and thereunder) and the adjacent shorelands (including the waters therein and thereunder), strongly influenced by each other and in the proximity to the shorelines of the several coastal States, and includes transitional and intertidal areas, salt marshes, wetlands and beaches." The zone extends in Great Lakes waters to the international boundary between the United States and Canada. The zone extends inland from the shoreline only to the extent necessary to control shorelands, the uses of which have a direct and significant effect on coastal waters. Each Great Lakes State determines its own inland boundary. The Shore Use and Erosion Work Group defined the shoreland zone as the land area one-half mile inland from the shoreline and two miles offshore. Obviously this definition is not binding on the Great Lakes States.

2.3 The Beach Profile and Surf Zone

The beach profile (Figure 12–5) is a relatively small physiographic feature whose limits are defined by the effects of waves. As waves approach the shore they reflect, diffract, or refract, while the beach acts as a natural defense against their attack. This action takes place in the surf zone (Figure 12–6).

The erosive energy of a wave is a function of wave height and the depth of water in which the wave acts. Wave energy is strongest in deep water, but its effect is greatest in the surf zone, from the start of breaking waves to the limit of run-up. The first defense against waves is a sloping shore bottom, which dissipates the energy of deepwater waves. Yet some waves continue toward the shore with tremendous force and energy until they break on the beach, unleashing their destructive energy. This process often builds an offshore bar in front of the beach, which helps to trip following waves. Offshore bars are an important feature of the Great Lakes beach profile. Beaches usually have one bar. Flat beaches with underwater slopes of less than 1:75 may have as many as three bars, although the inner one is usually poorly defined. The top of the inner bar is usually one to three feet below the water surface, while the second bar is 6 to 10 feet below the water, and the third bar is 12 to 15 below.

The offshore beach profiles, which are extremely important because they determine the relative stability of the beach foreshore, are classified as flat, moderate, or steep. On a flat beach, water is less than 10 feet deep 1,000 feet from the shoreline. Water on a steep beach is at least 30 feet deep 1,000 feet off the shoreline.

The beach slope is related to wave action and greatly controlled by the grain size of the beach material. Coarse sand materials form steep beach slopes while fine sand materials are usually found on flat beaches. When artificially nourishing beaches, every effort should be made to match the existing beach material or to use larger materials.

Great Lakes beaches contain a great variety of materials because they are composed of sediment reworked from glacial drift. Texturally these sediments range from silt-size particles to boulders, but, the great majority of beaches are composed of medium sand.

The beach slope also determines the extent the wave runs up the foreshore beach slope. The zone of wave run-up is defined by the extreme vertical position that the wave

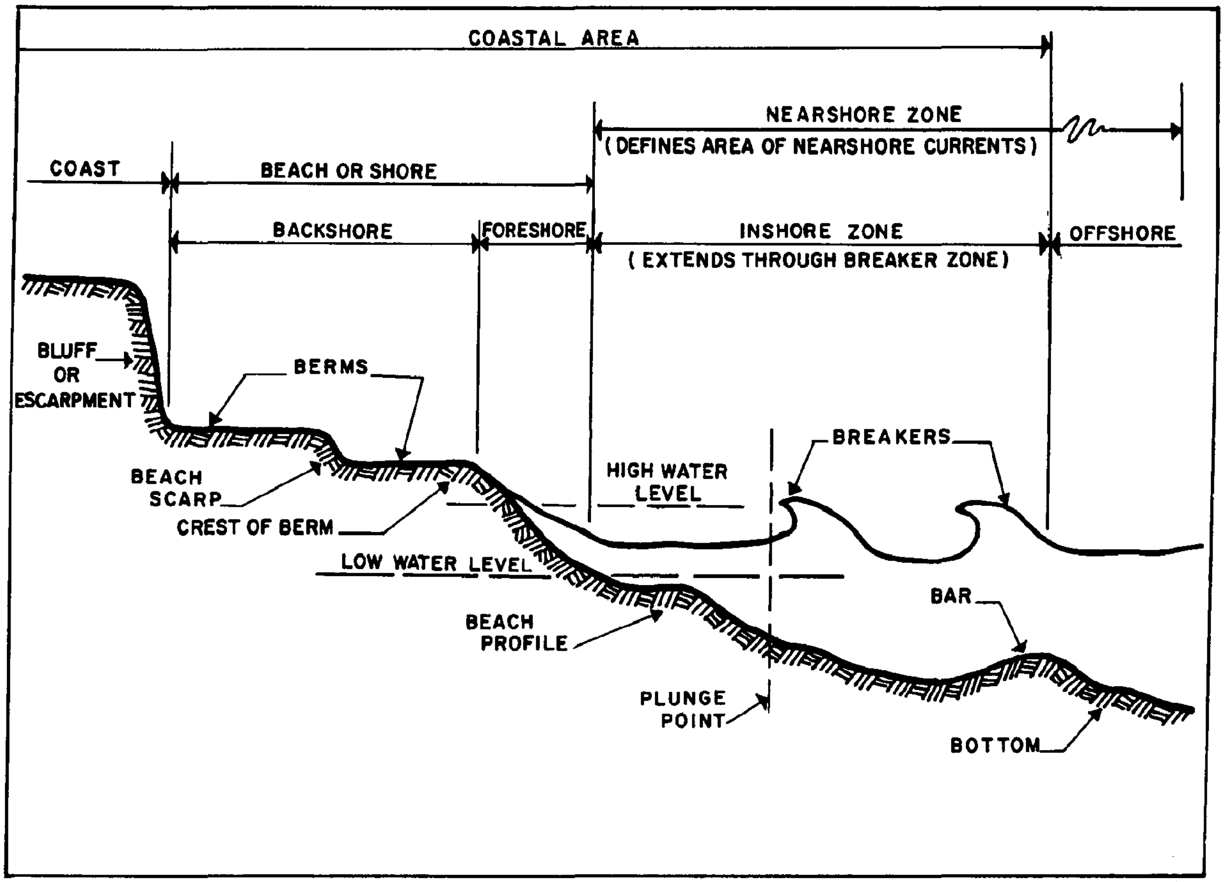

FIGURE 12–5 Beach Profile-Related Terms

reaches during a storm and by the still water line. High lake levels permit small waves and large broken waves to reach the highly erodible steep bluffs. The material in these banks is extremely unstable and large quantities slide into the lake when subject to direct wave attack. This results in a rapid landward movement of the bluff or upland shore. The number, position, and geometry of longshore sand bars are important variables in controlling the amount of wave energy reaching the beach and shore uplands. They control the distribution of wave energy through the surf zone.

2.3.1 Wave Heights

Knowledge of maximum wave conditions in the Great Lakes is essential for the design of shore protection to enhance the stability of the shoreline. Storm waves are random and of intermediate depth. Waves are classified as deepwater waves and shallow water waves. Deepwater wave conditions are determined from synoptic meteorological data and translated to the conditions at the site by refraction or diffraction analysis. Table 12–4 illustrates the expected once-a-year maximum wave heights, period ranges, probable directions of wave approach, and probable durations of maximum wave height at deepwater points immediately adjacent to designated shore areas. A shallow water wave is one traveling in water whose depth is one half the wave length and the bottom is altering the characteristics of the wave.

The surf zone, under which lies shifting sand, is the area where waves of various heights break, giving up most of their energy. Beaches that have a steep approach allow the swell to approach the shore without being slowed or changed until the last moment when it abruptly rises up and breaks directly on the beach face with great violence. These are called plunging breakers. In other areas the beach approach may shoal so gradually that

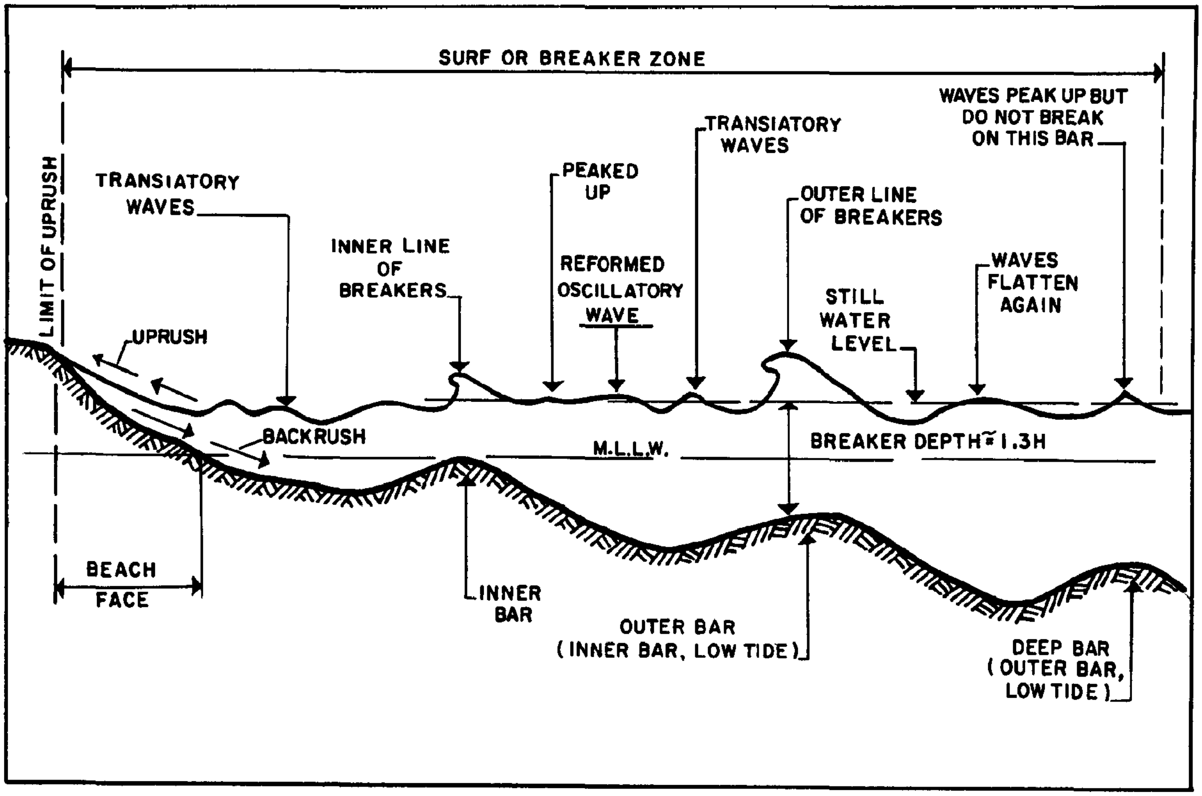

FIGURE 12–6 Schematic Diagram of Waves in the Breaker Zone

large waves may break and reform a number of times before the wave reaches the shore.

Sand particles in the surf zone are constantly moving in response to wave energy. When small waves approach the shoreline the sand moves shoreward. Low steep waves pick the sand up, move it forward, and deposit it on the beach berm. Large waves create turbulence, steepen the beach profile, and carry the sand lakeward where it is deposited in an offshore bar. After storm erosion, shallow nearshore bars migrate shoreward, replenishing some of the lost sediment (Figure 12–7).

Principal parts of a wave are:

crest—the high point of the wave

trough—low point of the wave

wave height (Ho)—vertical distance from trough to crest

wave length (L)—horizontal distance between crests

wave period (T)—time in seconds for a wave crest to traverse a distance equal to one wave length

The direct relationship between the wave length (L) and the wave period (T) is $L = 5.12(T^2)$ where L is in feet and T is in seconds. Steepness is the ratio of wave height to wave length and the upper limit is about 1:7 or 0.143. The wave period (T) and wave height (H) can be determined by counting the number of seconds between wave crests passing a fixed point (piling) and estimating the height of each wave.

The energy a wave delivers to a beach is most conveniently described in terms of wave steepness, the ratio of wave height to wave length, commonly written H/L. For example a six-foot wave 600 feet long has a steepness of 6/600 or 0.01. Steepness increases either with an increase in wave height or a decrease in wave length. Steep waves greater than 0.03 build high berms while cutting back the beach and forming an offshore bar. Shallow waves less than 0.03 bring sand ashore. The beach profile then is determined to a great extent by the average wave steepness.

Wave-generated currents, which transport beach material, are an important factor in beach stability. The direction of littoral drift is determined by the angle of wave approach and

TABLE 12-4 Probable Once-A-Year Significant Wave Height Values

Locality	Probable Once-A-Year Maximum Wave Height (Ho) (feet)	Period Range (seconds)	Probable Directions of Approach	Probable Duration (hours)
	Lake Superior			
Brule River	20	9-11	NE	6
Carver's Bay	27	11-13	NE	6
Little Lake	22	10-12	NW	8
North Shore	15	7-9	E or NE	6
Grand Marais (Mich.)	25	11-13	NE	6
Eagle Harbor	29	13-15	N or NE	8
	Lake Michigan			
North Bay	9	4-5	NE or S	6
Milwaukee	13	5-6	E	5
Chicago	8.5	4-7	N	9
Muskegon	15	5-7	SW	10
Frankfort	17	4-7	SW or WSW	9
Kenosha	13	7-9	E	5
Manitowoc	11	7-8	E	5
Berrien County	11	7-8	W or NW	5
Indiana	12	7-8	N or E	6
	Lake Huron			
North Point	9	5-6	NE or SE	6
Harbor Beach	13	5-7	E	5
Port Huron	8	4-6	N	9
	Lake Erie			
Cleveland	9	5-6	W or WNW	6
Erie	9	5-6	W or WNW	6
Buffalo	11	6-7	W	8
Huron	11	6-7	W or WNW	6
Monroe	8	5-6	E or ENE	6
Reno Beach	5	4-5	E or ENE	6
	Lake Ontario			
Olcott	9	5-6	W or WNW	6
Oswego	11	6-7	W or WNW	8
Fair Haven State Park	11	6-7	E or ENE	6
Fort Niagara State Park	12	6-7	E or ENE	6

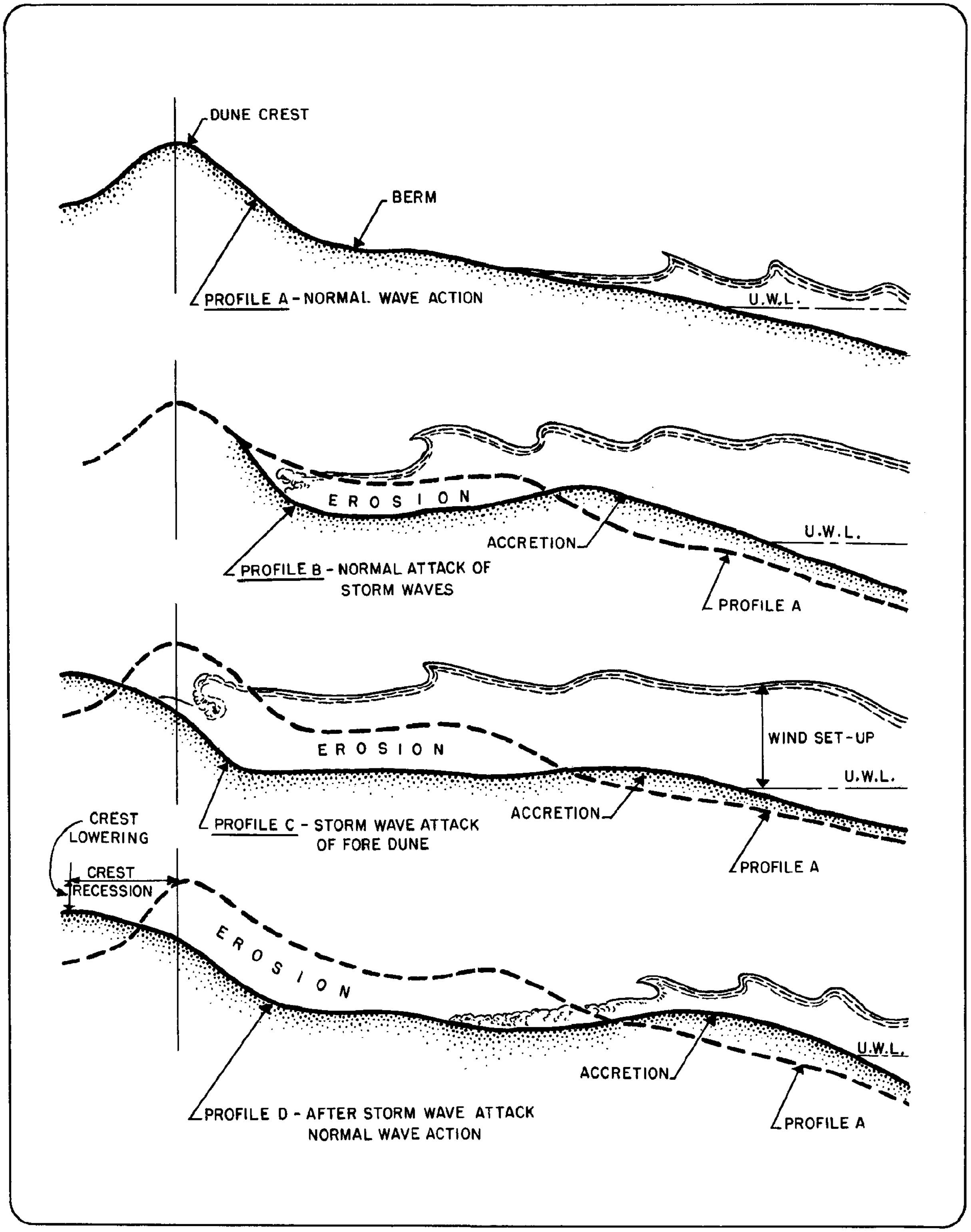

FIGURE 12–7 Storm Wave Attack on Erodible Shoreform

the direction of the longshore currents. The predominant direction of littoral drift depends on nonstorm waves that contain much more total energy than is contained in storm waves of shorter duration. An annual distribution of wave heights is shown in Figure 12–8. Sand from erodible shorelands can move offshore or alongshore. Wave-generated currents carry some particles along the bottom as bedload while other particles are carried some height above the bottom as suspended load. Finer materials such as silt and clay need little energy to keep them in suspension, and they usually escape from the surf zone to be carried long distances by the minor energy available in lake currents.

The various directions that littoral materials move and causes of losses or accretion are shown on a model of factors contributing to migration of the shoreline (Figure 12–9). Note that materials can move into and out of an erosion or accretion cell. The amount of erosion that occurs depends on the net difference in quantity of material moved in and out of the cell.

Movement of material does not stop with low lake levels, it only takes place further offshore and is less apparent. During periods of low lake levels waves still drive their energies onto the shore causing readjustment of the underwater offshore areas.

The shore-water interface is a dynamic system under stress by wave action that moves shore materials. Beaches constantly adjust to

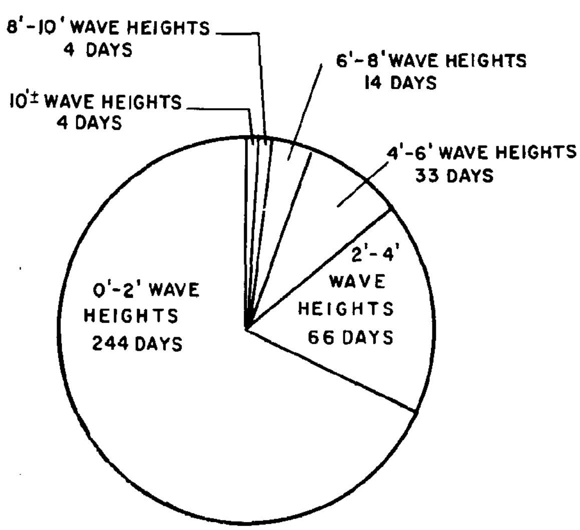

FIGURE 12–8 Distribution of Deep Water Wave Heights on Lake Michigan Offshore of Gary, Indiana, 1968–1970

accommodate different wave and water level conditions. Whenever man or nature interferes with the system, a different degree of erosion occurs somewhere. Erosion of the Great Lakes shoreline is continuing and would occur even if man did not exist.

If the natural balance of forces moving material to and from the beach is upset, the various forces will tend to establish another balance. A groin in its early stages, for example, interrupts alongshore drift causing accretion on the updrift side and, by preventing material from nourishing the downdrift side, causes erosion there. Similarly, rising lake levels upset the established balance of forces. This causes bluffs and beaches to erode at a more rapid rate and increases the amount of beach material available. The increased wave action on the beach also increases the rate of littoral transport. The first result favors beach accretion, and the second favors beach erosion. In the new balance, a beach may be expected to reform its equilibrium slope, but the foreshore moves landward pushing the berm to a correspondingly higher level.

Littoral drift directions are discussed in Subsections 2.3.1.1 through 2.3.1.5 and shown in Figure 12–10.

2.3.1.1 Lake Superior

Drift along the Minnesota shore of the Lake varies. It is generally west to east between Grand Marais and Grand Portage, and east to west in the general area south of Grand Marais. Along the southern shore from Duluth to the vicinity of Cornucopia the drift trends from east to west again, and then reverses to flow generally west to east to Copper Harbor. From there to the vicinity of Sault Ste. Marie the drift trends quite strongly from west to east.

2.3.1.2 Lake Michigan

Along the western shore in the vicinity of the north half of Door County Peninsula the direction of drift varies to such an extent that its up-coast and down-coast components are practically equal. North of Two Rivers, the drift is predmoninantly northward, and to the south the drift is predominantly southward. Around Milwaukee, the drift has a much stronger component toward the south. The tendency to drift southward continues to a point below Chicago, where the trend of the

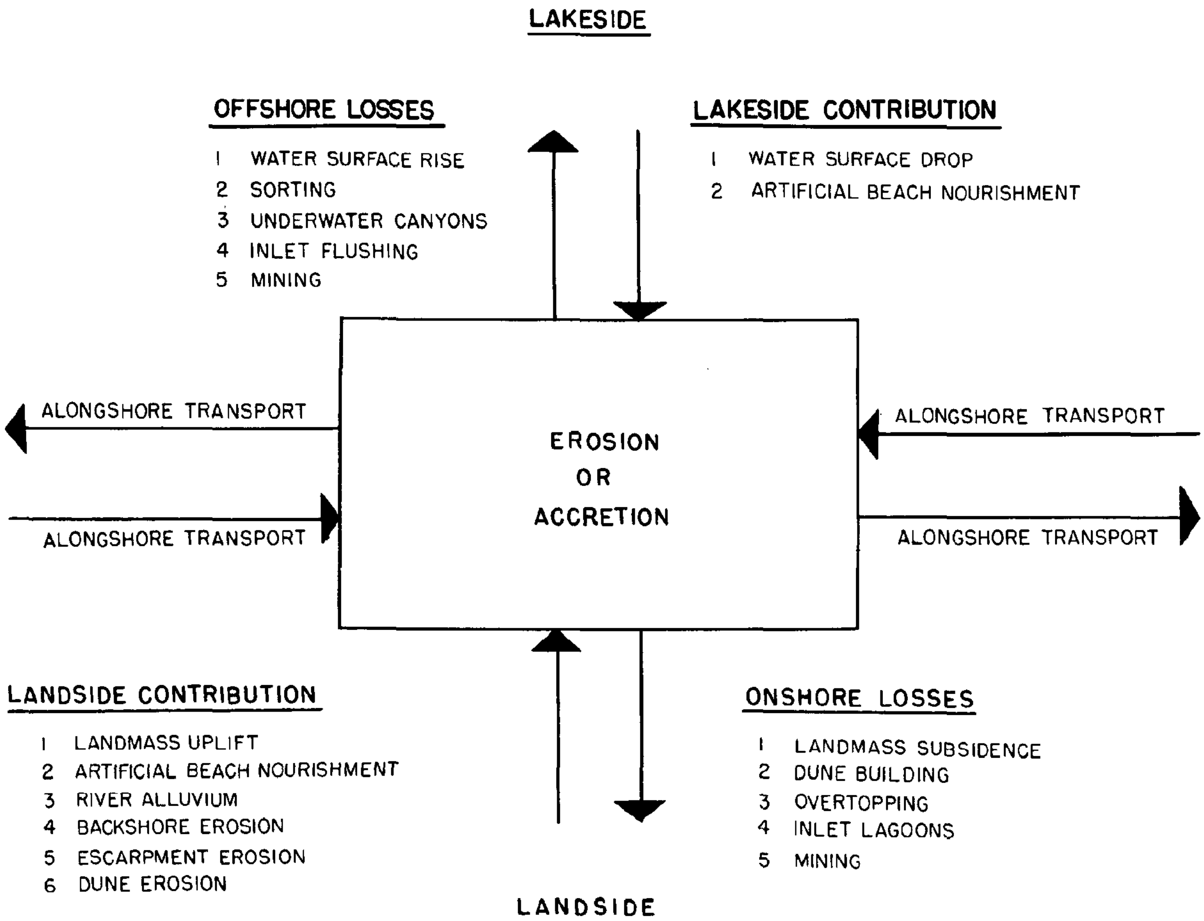

FIGURE 12–9 Factors Contributing to Migration of the Shoreline

coastline causes a reversal of drift. Along the eastern shore, somewhere between this nodal zone and Frankfort, the predominant drift is to the south. From Frankfort northward, the drift varies, but is predominantly northward.

2.3.1.3 Lake Huron

From Hammond Bay to Alpena, drift varies. From Alpena to the mouth of Saginaw Bay, the trend is southward. Saginaw Bay acts as a complete barrier to littoral drift, which resumes in the neighborhood of Port Hope and continues southward to Port Huron.

2.3.1.4 Lake Erie

West of Cleveland, the direction of drift varies. In certain areas the predominant direction is to the west, and in others it is to the east, but, from Cleveland to Buffalo, the drift is predominantly eastward.

2.3.1.5 Lake Ontario

From Youngstown to Olcott the direction of drift varies, but from Olcott to Port Ontario the predominant direction is to the east then it turns northward to Henderson Harbor.

2.4 Lake Levels and Temporary Fluctuations

A resume of data pertinent to the design of protective structures is given in the following paragraphs.

2.4.1 Lake Levels

Levels of the Great Lakes fluctuate irregu-

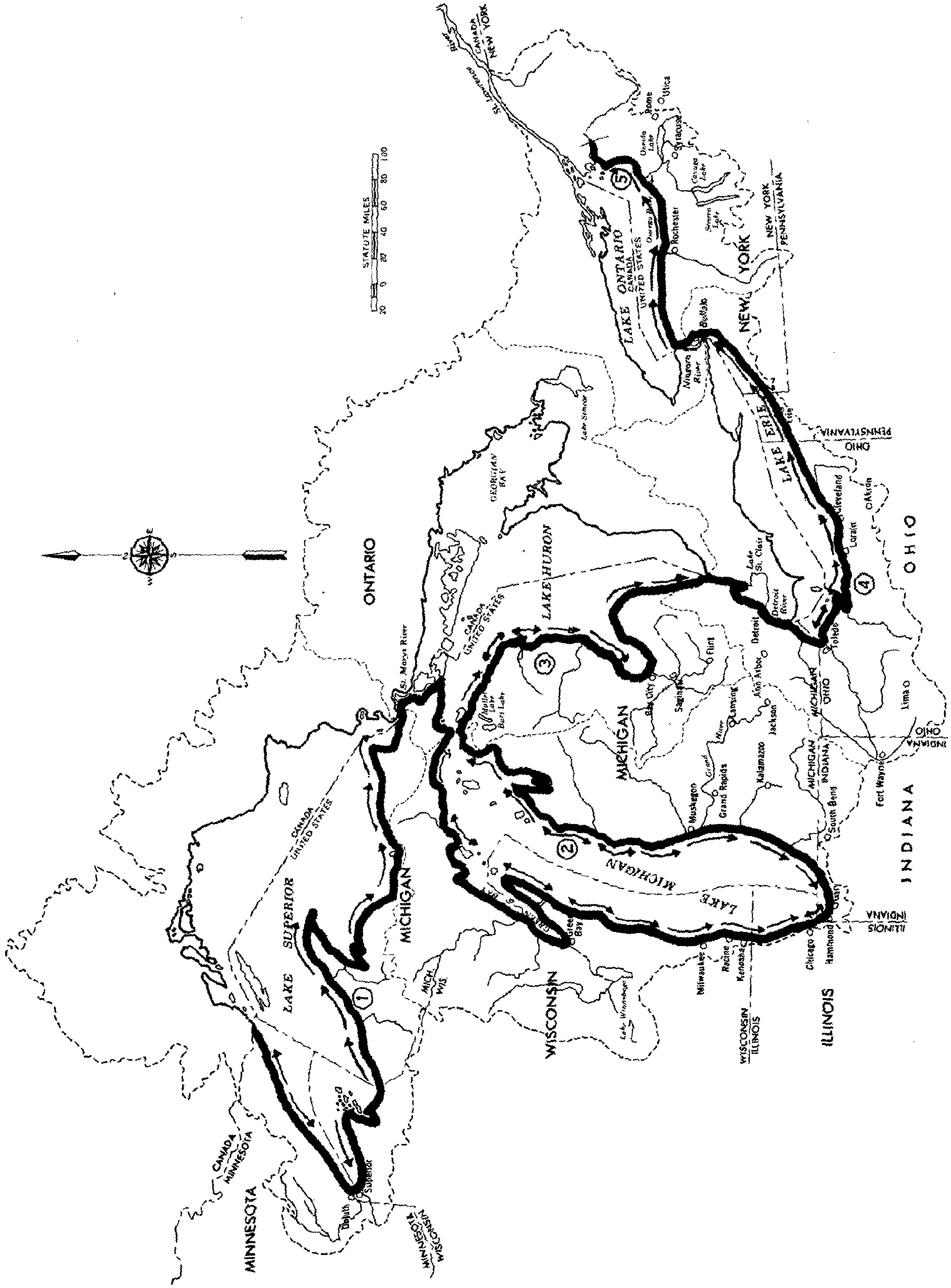

FIGURE 12-10 Net Direction of Littoral Transport, United States Shorelands of the Great Lak

larly from year to year and from month to month in each year depending on precipitation on the lake surfaces and land areas of the drainage basins. Variations in extractions of water from the lakes by outflow and evaporation also affect the Lake levels. The average seasonal pattern of variation shows low levels in the winter and high levels in the summer. The probable maximum monthly elevation and low water datum are, in feet:

Lake Superior, 601.7, 600.0
Lakes Michigan-Huron, 581.2, 576.8
Lake St. Clair, 576.2, 571.7
Lake Erie, 573.5, 568.6
Lake Ontario, 247.9, 242.8

2.4.2 Temporary Fluctuations

In addition to the long-term and seasonal variations, the Great Lakes are subject to irregular oscillations. Variations in barometric pressure produce changes ranging from a few inches to several feet. These temporary fluctuations may extend over a few minutes or several days. At times the lake levels are affected by winds. Sufficient velocity drives the surface water forward in greater volume than it can be carried by return currents, raising the lake elevation on the lee shore and lowering it on the weather shore. The magnitude of these short period fluctuations depends on local conditions. The maximum rises recorded on the Lakes and their frequenty of occurrence are given in Table 12–5.

2.5 Great Lakes Flood Problems

The Great Lakes flood plain, which is usually dry, but subject to flooding, is the lowland that borders the Lakes and connecting rivers. Damaging floods occur along the Great Lakes as a result of lake level fluctuations. The long-term range of levels varies from 3.8 feet on Lake Superior to 6.6 feet on Lakes Michigan-Huron and Lake Ontario. High lake levels can be increased as much as eight feet by short-period fluctuations resulting from winds and differences in barometric pressure. Superimposed on these fluctuations are wind-induced waves. The flood plains of the Great Lakes are limited to the low plain shore type (Pe) (Pn), but flooding also occurs at the mouth of rivers, where ice forms often complicate flood problems. The severity of floods is directly related to the lake stage and wave heights. Economic losses from floods result from man's use of

TABLE 12–5 Frequency of Maximum Short Period Fluctuations

Lake	Gage Location	Maximum Rise In Feet	Frequency of One Such Rise In Years
Superior	Two Harbors*	2.1	10.00
Superior	Marquette	2.8	43.50
Superior	Point Iroquois*	2.3	8.50
Michigan-Huron	Mackinaw City	1.7	13.50
Michigan	Ludington-White Lake*	1.2	4.25
Michigan	Calumet Harbor	2.8	29.00
Michigan	Milwaukee	2.3	36.75
Michigan	Sturgeon Bay Canal*	1.7	3.25
Huron	Harbor Beach	2.1	45.75
Huron	Fort Gratiot (Port Huron)*	2.5	9.50
Erie	Gibralter*	3.0	9.75
Erie	Toledo	4.5	10.00
Erie	Put-In-Bay*	2.4	8.50
Erie	Cleveland	2.7	46.50
Erie	Buffalo	8.4	48.25
Ontario	Oswego	2.1	9.50
Ontario	Tibbetts Point	2.9	15.75

*Comparatively short records

flood-prone areas. However, the flood plains of the Great Lakes offer advantages that tend to compensate for the flood hazards.

2.6 Great Lakes Shore Erosion Problems

The severity of shore erosion, a major water resource problem on the Great Lakes, depends on the orientation of the shoreline, the offshore depths, and the resistance of the shoreline to wave action. Other factors include water levels, wind strength, duration, and orientation and fetch. An erosion problem should be described in terms of exposure (open or sheltered), remaining beach (narrow or no beach), beach and upland material, offshore slope (flat, moderate, or steep), and the upland shore form.

Erosion on the Great Lakes is caused principally by storm-induced wave action and associated alongshore currents, and is particularly critical during periods of high lake levels when the beaches, which might protect adjoining highly erodible upland areas, are submerged. Once above the beaches, wave forces impinge directly on the toe of the bluffs and dunes, which if composed of erodible material, recede rapidly.

As outlined in the Introduction, Great Lakes shorelands have been classified on the basis of 10 basic shore types, according to the topography and erodibility. Those shore types consisting of clays, sands, and gravels have been classified as erodible, and those of hard shales and rock are considered nonerodible. Approximately 60 percent of the Great Lakes shorelands consist of erodible shore types. Fifty percent of the erodible shorelands are economically developed with residential, industrial, commercial, and public lands and buildings. The remaining 50 percent of the erodible shorelands consist of recreational, agricultural, forested, or undeveloped lands.

Existing shoreland erosion and flooding problem areas are identified on detailed maps in Attachment B. The critical erosion areas, as opposed to noncritical, are those reaches of shore where the rate of erosion, considered in conjunction with economic, industrial, recreational, agricultural, navigational, demographic, ecological, and other relevant factors, indicates that action to halt erosion may be justified. In attempting to identify serious erosion areas that will soon require remedial action, the Shore Use and Erosion Work Group's judgment was necessarily subjective. Many of the noncritical areas will become critical if adequate protection is not provided or if other nonstructural measures are not undertaken to limit damage due to erosion. Proper management of future use and development is essential in these areas.

2.7 Other Management Needs and Problems

A comprehensive approach to shoreland planning calls for extensive efforts to identify a full range of shoreland needs and problems. The intent here is to see how the preservation and enhancement of the shore can play a part in satisfying a broad spectrum of coastal zone uses. These needs and problems are developed in Subsection 3.2.9.

2.8 Shore Protection Measures

Shorelands are a limited resource filled with competing and noncompatible uses such as housing, commerce, industry, recreation, and open space. Planning in the coastal zone also presents the fundamental question: to what extent should man change the natural environment to accommodate his uses of the coastal zone? Section 1, Planning Framework for the Great Lakes Shorelands, suggests that structures should not be introduced into the beach profile zone, that primary dunes must be protected, and Great Lakes shorelands should be affected as little as possible.

However, approximately 40 percent of the erodible shorelands are already developed for industry, commerce, recreation, and residential use so that the question of shoreland use has been decided. Existing development along erosion-prone shorelines will eventually require structural control measures to stabilize shorelines or be sacrificed to the Lakes.

2.8.1 Data Acquisition

It is important to understand the geographic and hydrographic conditions of the Lakes so that everything possible can be done to reduce erosion damages. The first step in the design of shore protection is to learn as much as possible about the expected wave conditions. While some State and Federal research and data collection activities now exist they are not adequate to cover all possible problems on the Great Lakes.

Methods of recording data must be standardized so that consistent, usable data can be obtained. Data collection activities emphasizing periodic visual observations, photographic records, and standard recording formats are developed in the Corps of Engineers Littoral Environmental Observation (LEO) Program. Data parameters should be arranged as follows:

(1) location of the recorder—identify shoreland location with respect to the distance to nearest permanent structure, i.e., breakwater

(2) wave data—including wave period, wave height, wave direction, wave type, beach and wind compass direction and alignment, wind speed, and littoral drift

(a) wave period: Count the number of seconds between waves passing a fixed point (i.e., piling). Wave period should vary between 2 and 10 seconds.

(b) wave height: Look for the lines of breakers during storms. Large waves approaching a flat offshore beach profile will break a considerable distance offshore, then reform as smaller waves and break again with decreasing force. Record the number of breaker lines, the distance offshore, and the height of each breaker. The breaker height can be determined by locating yourself so that your eye is in line with the top of the breaker and the horizon and then measuring the vertical distance from your eye to the shoreline when the water is calm. Deepwater wave heights on the Great Lakes vary between 0 and 20 feet.

(c) wave direction: Deepwater lake waves will approach the beach profile from the general wind direction. The data needed for design is the final wave height of the refracted and broken waves as they approach the beach. The observer must record the compass direction of the waves and the beach.

(d) wave type: A spilling wave occurs when the wave crest becomes unstable at the top and the crest flows down the face of the wave, producing an irregular, foamy water surface.

A plunging wave occurs when the wave crest curls over the face of the wave and falls into the base of the wave, producing a high splash and much foam.

A surging wave occurs when the wave crest remains unbroken while the base of the face of the wave advances up the beach.

(e) wind direction and speed: Wind direction is the compass direction from which the wind is coming. A wind meter is needed to measure wind velocities.

(f) littoral drift: Littoral drift observations and quantity estimates are needed to determine structural or nourishment measures. An obstacle placed across a littoral stream flowing along the shoreline causes deposition of much of the littoral material on the updrift side of the obstacle until equilibrium profile is reached and transport can continue around the obstacle.

(3) beach data—berm height, lake elevation, beach length, shore slope, water depth 1000 feet lakeward of shore, and distance to and height of offshore bars

(a) berm height: Measure the vertical distance from the shoreline to the top of the berm or the toe of the bluff.

(b) beach length: Measure the length of beach from the shoreline to the top of the bluff or the berm (at calm water).

(c) shore slope: Divide berm height by shore length.

(d) offshore topography: Determine offshore depth from shoreline to 1000 feet. Take soundings with a weighted and calibrated line (lead line) from a boat. Record depths at 100-foot intervals, attempting to locate offshore bars. Monitor the offshore bar locations. Carefully measure and record the offshore depth 125 feet from the shoreline.

Basic observations and measurements and their desired frequency are

(1) wave observations—twice daily; height, period, direction, and type of breaking wave

(2) wind observations/measurements—twice daily; velocity and direction

(3) littoral drift observations—weekly; before and after surveys

(4) beach measurements—weekly; berm width and elevation, and slope of foreshore beach

(5) photographs—monthly; general panoramic photographs of the beach in up-and-down coast directions

2.8.2 Alternative Shore Protection Methods

One of the three basic means of protecting shores from wave attack and associated currents involves providing another source of movable material such as beach fill and periodic nourishment to absorb the energy of waves and currents. Beach materials may be protected from waves by structures such as bulkheads, seawalls, revetments, and offshore breakwaters. The third method retains beach materials by entrapment with groins or submerged offshore structures, which form perched beaches.

Shore protection measures may also be classified by performance and cost. Permanent shore protection structures provide a high degree of protection and require little maintenance, but cost a great deal. Semipermanent shore protection measures provide a lower degree of protection, require some maintenance, and have moderate cost. Finally, shore protection measures that cost little to construct may be temporary (lasting only one storm), provide a low degree of protection, and require constant maintenance.

There is no single type of protection that can be used in all cases. The most suitable type of individual sections must be determined by study and analysis. Low cost emergency protection can be provided for approximately $15 per foot, while permanent protection might cost more than $500 per foot of beach. Shore protection measures usually require a coordinated plan for an entire reach of shoreline. Scattered protective works are frequently ineffective because they are outflanked by problems on adjacent shore property. It is wise, then, for neighboring property owners or each community on the Great Lakes to work together to provide a shore protection plan.

2.8.2.1 Selecting a Protection Plan

The most suitable type of protection can be determined by consideration of the topography, soil conditions, wave climate, water surface elevations, adjacent structures, degree of development, amount of littoral materials, and availability of construction materials in the area.

2.8.2.2 Design Guidelines

The following six rules represent a starting point in designing successful seawalls, revetments, groins, offshore breakwaters, or perched beaches.

(1) Check foundation conditions. The type of foundation may govern the selection of the type of protection. For example, a rock bottom does not permit the use of sheet piling. A highly erodible, fine material requires a filter layer to prevent fine material from washing through the voids in the structure. A soft foundation material may result in excessive settlement of the structure. Clay layers under the structure could allow part of it to slide.

(2) Provide adequate protection just offshore of the structure so that it will not be undermined. Most failures of shore protection works are caused by "toe failure" or erosion under the lowest part of the structure subjected to wave attack. Toe protection must be substantial enough to prevent ground under it from washing through the toe protection blanket, and it must extend far enough lakeward to prevent undermining of the structure.

(3) Use material that is heavy enough. Waves have tremendous power and can move a lot of material in a short time. Protective works often fail because of undersized material.

(4) Make sure that underlying material is not washed out by waves. Protection material must be thick enough to keep wave energy from reaching underlying materials. A layer or two of filter material may be required between the underlying ground and the protective material. Fine sand and silt, for example, can be washed out through the interlocks of steel sheet piling.

(5) To stop adjacent erosion secure both ends of shore protection works against outflanking by tying into a natural hardpoint or other protected areas. In the absence of these two conditions build a hardpoint with more material at the ends than at the center and place it well back into the bench, berm, or bluff.

(6) Build the structure high enough so that overtopping waves cannot erode material behind the structure as if the barrier were not there (some spray overtopping might be tolerated).

It is highly desirable to get competent engineering assistance in the selection of alternative means and design of shore protection. Properly engineered structures will, in the long run, save time, money, effort, and worry.

2.8.3 Structural Shore Protection Measures

Typical shore protection measures, illustrated in Figures 12–11 through 12–14, are outlined in this subsection with their advantages and disadvantages. Also included are estimates of costs and general planning criteria. The most comprehensive publication on planning and design of shore protection structures is entitled *Technical Report No. 4, Shore Protection Planning and Design*. Prepared by the Coastal Engineering Research Center, Corps of Engineers, it synthesizes most available knowledge on coastal engineering.

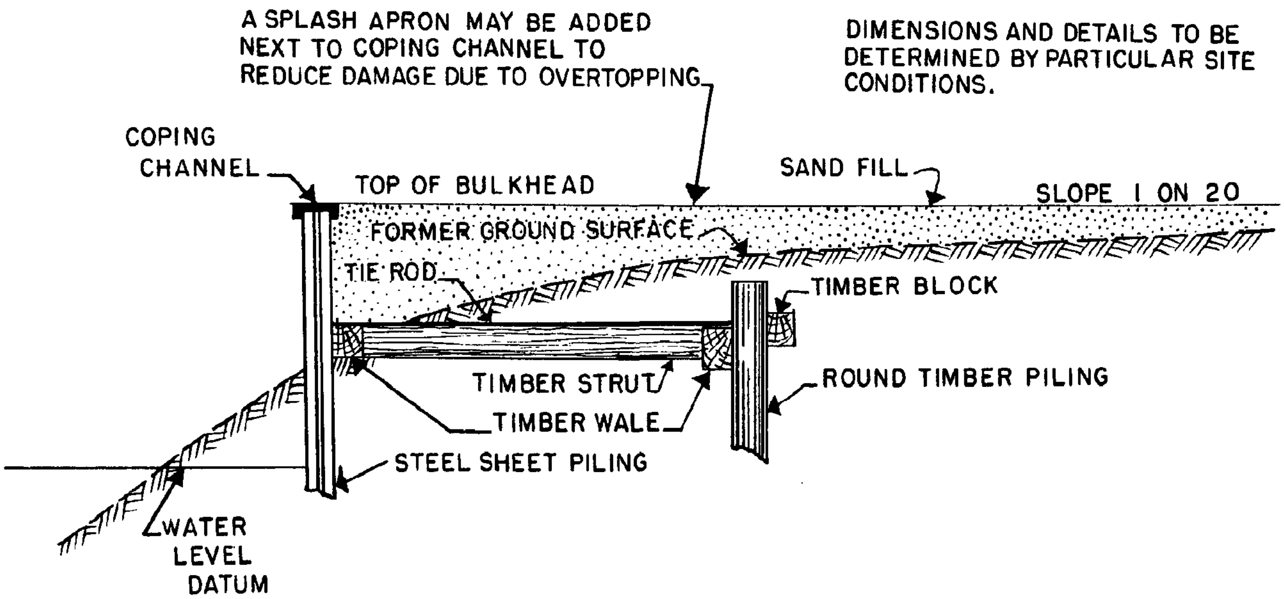

FIGURE 12–11 Typical Steel Sheet Pile Bulkhead

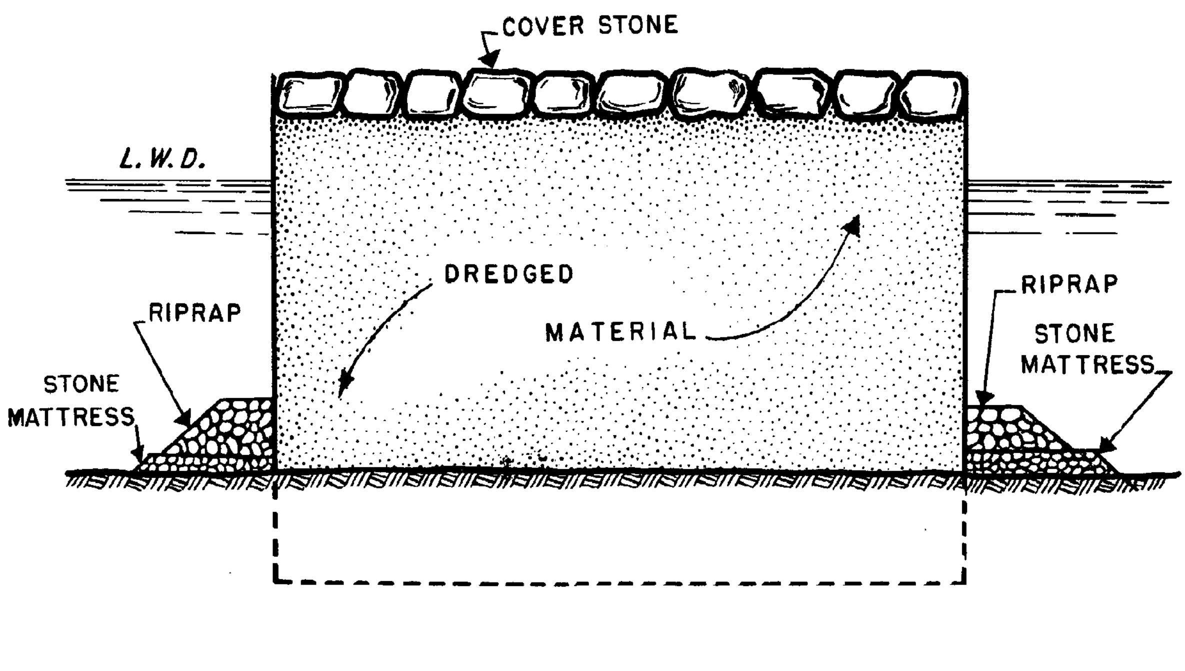

FIGURE 12–12 Typical Cellular Steel Sheet Pile Breakwater

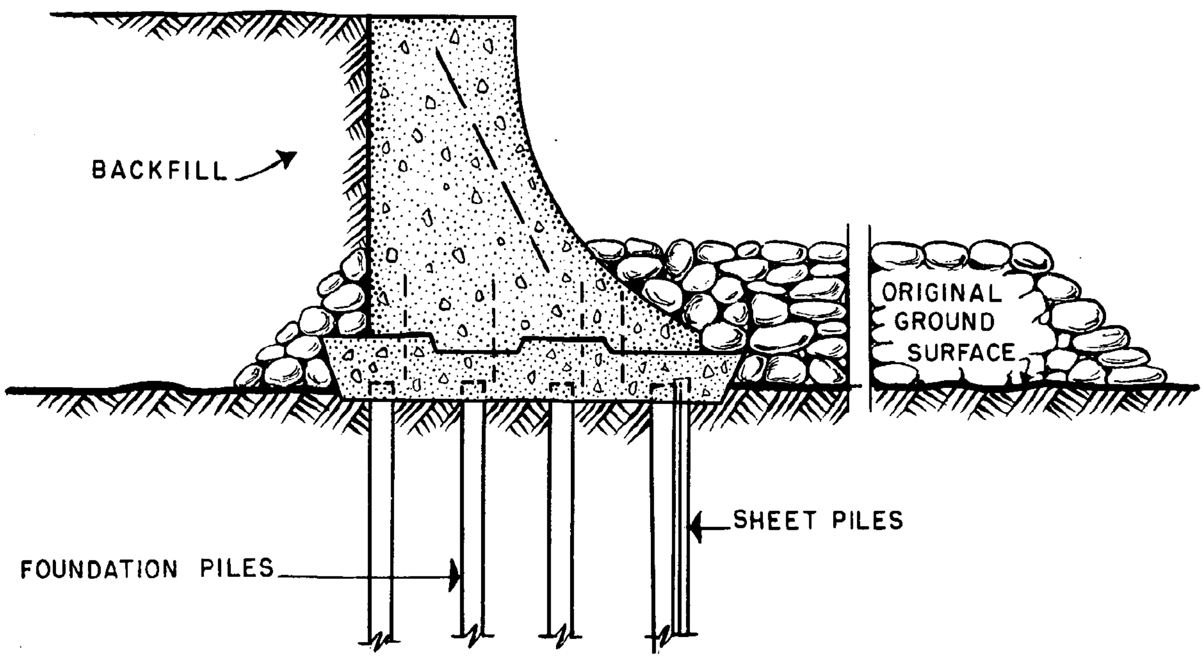

FIGURE 12–13 Typical Concrete Curved-Face Seawall

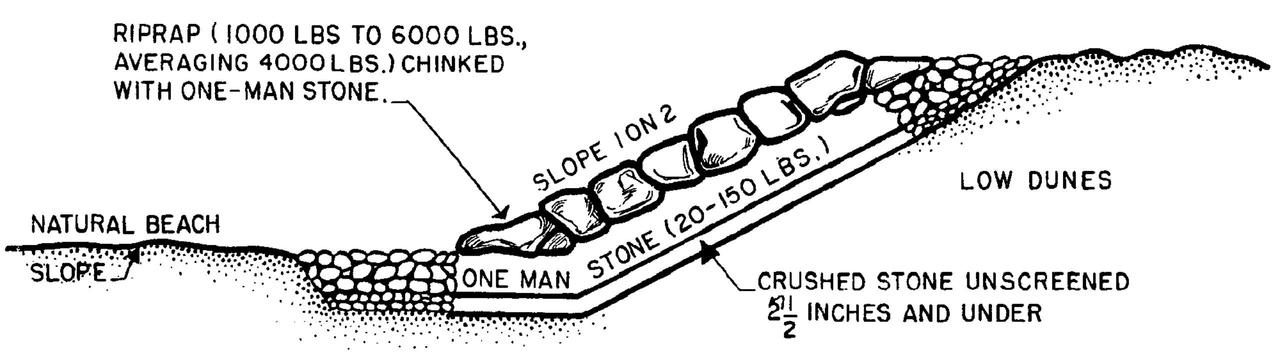

FIGURE 12–14 Typical Riprap Revetment

2.8.3.1 Bulkheads, Seawalls, and Revetments

Bulkheads are primarily used to resist earth pressures and to prevent landslides. Their secondary purpose is to protect the backshore from damage by wave action. Seawalls and revetments also protect the backshore from wave action while incidentally acting as retaining walls.

There are three advantages to using bulkheads, seawalls, and revetments:

(1) provide positive protection
(2) maintain backshore in a fixed position
(3) provide spot protection to short reaches of shore

The disadvantages include:

(1) not effective in maintaining a beach
(2) provide no protection to adjacent shores, which will continue to erode and will eventually expose flanks of the protected property
(3) limit access to water by property owners

Bulkheads and revetments cost approximately $75 to $300 per foot of protection. Seawalls cost approximately $200 to $500 per foot of protection.

Planning criteria for these measures include determination of the use and overall shape of structure, the location of the structure with respect to the shoreline, the height and length of the structure, the construction materials, and the construction technique. The design of the filter material behind a revetment is very important.

2.8.3.2 Offshore Breakwaters

Offshore breakwaters are constructed parallel to the shore to provide protection by preventing waves from reaching the shore. Their advantages include:

(1) providing protection without impairing the usefulness of the beach
(2) providing sheltered water for boating

Their disadvantages are:

(1) high cost of construction
(2) elimination of wave action behind them reducing littoral transport and causing starvation and erosion of downdrift beaches

These structures cost from $200 to $500 per foot of shore protected.

Planning criteria should include determination of the location of the structure with respect to the shoreline, the length and height of the structure, type of construction materials, and effect of structure on downdrift beaches.

2.8.3.3 Beach Nourishment

Beach nourishment is a means of dissipating wave energy in order to keep wave action from reaching the erodible backshore. The advantages of this process are:

(1) Beaches can have considerable recreational value.
(2) This treatment remedies the basic cause of most erosion problems, that is, deficiency in natural sand supply, and therefore benefits rather than damages downdrift shores.

The principal limitation of artificial beach construction is the inability to locate an adequate economical supply of suitable beach material.

The process costs from $200 to $400 per foot of beach depending on exposure, proximity of suitable fill borrow sites, length of beach, and degree of protection desired.

Planning criteria include:

(1) determination of the predominant direction of littoral transport and deficiency of material supply to the problem area
(2) determination of the composite average characteristics of existing beach material or native sand
(3) evaluation and selection of borrow material for initial beach fill and periodic nourishment
(4) determination of beach berm elevation and width, and wave adjusted foreshore slope
(5) determination of whether structures such as groins are needed to maintain a stable beach at a reasonable cost

2.8.3.4 Groins

Groins are constructed to build, widen, or stabilize an existing protective beach by trapping littoral material. This keeps wave action from reaching the erodible backshore.

Groins are desirable for various reasons:

(1) The resulting beach provides protection to upland areas as well as a potential recreation area.
(2) Their effect may spread over considerable lengths of shore.
(3) At those locations where groins would be effective, protection can generally be provided at lower initial cost by their use.

Their disadvantages are:

(1) Groins are not as effective as a seawall for continuous upland protection.
(2) They may be outflanked.
(3) They are ineffective in areas of low lit-

toral drift unless granular beach fill is artificially added.

(4) The area immediately downdrift of the groin may be subject to increased erosion.

Groins cost from $100 to $300 per foot of shore protected. This is the cost range for groin structures only. Where beach fill is also required to prevent adverse effect on downdrift shores, the cost increases accordingly.

Planning criteria include:

(1) determination of the amount and direction of littoral drift in the problem area and the groin dimensions and spacing

(2) determination of the need for artificial beach fill for initial construction and subsequent maintenance

(3) determination of the effects of groins on downdrift beaches

Section 3

SHORELAND MANAGEMENT MEASURES

3.1 Introduction

The planning approach to a shoreland management program involves both evaluation and action. In the decision-making process one must define the planning context, derive shore objectives and value criteria, and examine techniques for achieving objectives. Also included are the formulation and implementation of a shoreland plan.

Shoreland planning can be accomplished at many different levels with different degrees of comprehensiveness. The first step in the process is to determine the scope of the effort and the limits of the planning area. Considered here are the levels of government, the participants and their roles, a plan formulation value system, regional and national needs, and technical expertise in research engineering and leadership.

3.2 Objectives

The objectives of water resource planning, national economic development and environmental quality, are considered in shoreland planning through the allocation of permissible land and water uses or structural modifications to shoreland resources. These uses include residential, industrial, and commercial development; recreation and urban open space use; extraction of mineral resources; power plant sitings; navigation and recreational boat harbors; waste disposal and water intake structures; and living resources. Other planning considerations include ecological, cultural, aesthetic, and historical values and economics.

The following should be considered in shoreland planning in terms of present and future needs and in terms of the importance people attribute to them:

(1) health and safety
(2) employment
(3) community cohesion
(4) desirable community growth
(5) housing
(6) land use and ownership
(7) water supplies
(8) forest products
(9) education and scientific values
(10) urban flood and erosion protection
(11) transportation
(12) parks and open space qualities and terrestrial resources
(13) hunting and fishing opportunities
(14) public access to water and scenic areas
(15) boating
(16) swimming
(17) areas of natural beauty and human enjoyment
(18) archeological, historical and cultural values
(19) unique resources
(20) wilderness qualities
(21) power
(22) water quality
(23) aquatic resources

Shore management should evaluate needs for preserving and enhancing the shore resources, examine techniques to satisfy needs, formulate a plan or series of plans for the shoreline, and decide how to implement the plan. Preservation is defined as essentially maintaining the undeveloped shorelands in their natural state. Enhancement means modifying the shorelands in a way judged by society to be desirable. Both preservation and enhancement may serve society, or the ecological balance, or both. In general shore management procedures involve answering questions. Who is to do the necessary planning? What kind of shore is needed? What techniques are available for satisfying needs or correcting problems? How can these needs and techniques be formulated into a plan or plans? How can the plan be implemented?

3.2.1 Shoreland Planning Responsibility

Shoreland planning can be carried out at many levels. A single individual may be responsible for planning shore protection for his shoreland property, or a large interdisciplinary group, e.g., the Great Lakes Basin Commission, may be concerned with developing a comprehensive large-scale, multi-use, long-range plan for the region. In the Great Lakes Region the majority of shoreland planning is conducted by private shore property owners, who are responsible for 83 percent of the shoreline. The individual shore property owner, who makes decisions on available knowledge and his perception of needs, uses a single purpose and utilitarian planning context. During low lake levels, he might focus on the recreational use of his beach. When high lake levels come, his concern turns to protecting his shorelands from erosion. He does not possess the knowledge needed to evaluate his problems and needs within a larger context, and he is usually not aware of the consequences of his decisions or that some of his decisions are irreversible.

The large interdisciplinary planning group is staffed with both inland- and marine-oriented personnel. Agencies involved in coastal management have the expertise to apply to the complex problems of the coastal zone, but concerned with regional or national issues and values, they have little appreciation of the problems of individual property owners.

There must be a merger of these two diverse interests at the level of government appropriate for the intended scope of planning. In the Great Lakes Region, the States may be the focal point with considerable support from the Federal, regional, and local levels.

3.2.2 Permissible Shoreland Uses

Problems and needs of shorelands relate specifically to shoreland use and value. The concept of demand-supply-need is used here to quantify needs for preservation or enhancement of shoreland resources (Figure 12-15).

Demand is the public's desire, expressed in appropriate terms, for a certain use. For example, demand for beach recreation might be expressed in user days or design attendance. Demand for the extraction of living resources might be expressed in terms of fish catch, while demand for waste disposal is expressed in terms of approved water quality standards.

Shore requirements are the demand converted into related shore conditions. They might be expressed as an amount of beach of a certain type that can satisfy a level of recreational user-day demand, or as inlet or wetland conditions contributing to a desired fish

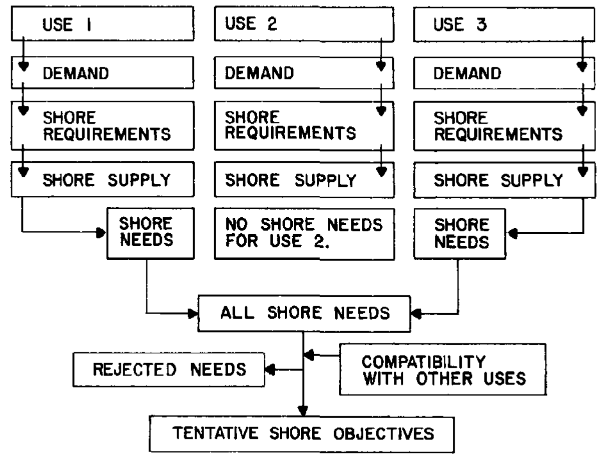

FIGURE 12-15 Derivation of Tentative Shore Objectives

catch, or inlet conditions affecting flushing characteristics of importance in satisfying water quality standards. Translation of demand to shore requirements, which frequently requires ingenuity and research, is critical to subsequent analysis. This is particularly true for ecological requirements. When the general demand for ecological preservation and enhancement is apparently great, scientific studies are often necessary to translate this demand into related shore conditions.

Shore supply is the condition of the shore in terms of shore requirements. It might be a descriptive inventory of pertinent shore conditions.

The term shore needs denotes a deficiency: the shore requirements less shore supply. When compiling shoreland needs for the Great Lakes Region, some trade-offs are necessary to resolve the conflicting demands and insufficient resources.

3.2.2.1 Beach Recreation

Beach recreation demand is usually expressed in terms of designed attendance, the peak number of people who can be expected to be on the beach simultaneously during a selected day. The most popular form of beach recreation is swimming.

Shore requirements are usually taken as the area of beach of a stipulated quality required to accommodate the demand, using density standards in the number of square feet per user during design attendance. A realistic but liberal standard is 100 square feet of beach per person for the design attendance.

Acceptable beach densities vary from as low as 20 square feet per person to as high as 300 square feet per person, depending upon regional user experiences.

Shore needs are determined by subtracting the beach supply from the beach requirements. The subtraction is straightforward when requirements and supply are developed in compatible terms.

3.2.2.2 Other Types of Recreation and Aesthetic Appreciation

This process of determining shore needs by first determining shore demand, requirements, and supply is applicable to other types of recreation, including aesthetic appreciation. Particularly low density standards are required frequently for that use.

Shore requirements for boating can be conceived in terms of an amount of protected water surface with adequate marinas and points of access near population centers. Further distinctions can be made for various classes of boats. For example, a shortage of boat ramps might limit use of a body of water by small craft.

Sport fishing requires extensive, remote, and well-vegetated wetlands and shoal areas. Further distinctions can be made for various species, bottom conditions, protected fishing areas, shoreline fishing points, and underwater reefs. Sport fishing can also benefit from improvements made primarily for boating, provided that ecological implications are respected.

Hunting requires the preservation of extensive, remote, and well-vegetated wetlands. Wetlands are also essential in the food chain and serve as an important source of nutrients for marine life.

For aesthetic appreciation one needs extensive undisturbed shoreland observable from reasonably accessible vantage points. Other nonscenic forms of aesthetic appreciation such as historical areas, if identifiable, can also be reflected in terms of shoreland requirements. A developed shoreland can also have aesthetic appeal. Figure 12–15 shows the procedure for arriving at a tentative shore objective where the three uses are involved.

3.2.3 Waste Disposal

The strong public demand for water of high quality is made more tangible when expressed in the form of approved water quality standards. These standards are derived from study, hearings, and review, and reflect a compromise between the need to dispose of wastes and the quality required for other coastal uses.

The condition of the shore usually does not play a major role in satisfying water quality standards except in special circumstances, when protection of silt-clay shorelines from erosion can reduce turbidity. This is true along the south shore of Lake Erie.

3.2.4 Transportation

Shore conditions important to marine transportation, one of the principal uses of the shoreland zone, are included in Appendix C9, *Commercial Navigation*, and Appendix R9, *Recreational Boating.*

3.2.5 Residential, Industrial, and Commercial Development

Residential demand for shore space, particularly for summer homes, is increasing rapidly. Many lots that sold for approximately \$500 in 1955 now command \$15,000. Shore needs particularly applicable to residential development might be expressed in terms of land suitable for building and adjacent to the lakefront with a beach large enough for both the resident's use and for storm protection, but inaccessible enough to discourage mass public use. Other desirable needs include a sweeping view of the lake and adjacent channels leading to waters desirable for boating and fishing. Such needs can be expected to become increasingly more prominent as projected changes in population, affluence, leisure, mobility, and environmental appreciation increase demand for a vacation home along the water.

3.2.6 Ecological Use

A shore in a natural state undisturbed by man is often valuable for ecological balance, and an important use of the coastal zone not always given adequate attention. The land-lake interface is complex in terms of both its living and non-living characteristics and their inter-relationships. The sensitivity to change of some aspects of this environment has been delineated, but its general resiliency is unknown. It is expected to be relatively fragile. A change in shore conditions, whether caused by man or natural forces, can set off a chain reaction which could detrimentally affect this total balance.

From this important ecological point of view, all shoreline conditions that affect this balance are important. Man-induced changes in the natural state, such as filling in a wetland or mining sand from a dune, should be evaluated for irreversible or significant ecological impacts. Special studies are usually required before changing shoreline conditions.

One way of focusing attention on ecological balance is to delineate especially sensitive coastal areas and factors. Inventory of current ecological conditions and the relevance of shore conditions in these areas is best done by life scientists who can determine what type of change will affect which species at which locations and times in what way. Man-made or natural changes may benefit or damage the ecosystem, or be inconsequential, but if they upset the ecological balance, they can affect both non-human life and man himself in ways that are only beginning to be understood.

3.2.7 Living Resource Extraction

The principal living resource extracted commercially from coastal waters is fish. The value of the fish catch in each planning subarea and the importance placed upon marine life in general may indicate an important general demand for the increasing resource. Appendix 8, *Fish*, provides information on this resource.

Biologists characterize most estuarine ecosystems as vital, fragile, and very sensitive to small changes. Reacting to these findings, inland river basin planning is increasingly attentive to conditions at the river mouths.

Many other relationships can be translated into shore needs that express possible deficiencies in shore conditions important to marine life. Examples are the need for freshwater wetlands and shoal areas, vegetative cover, access channels to wetlands for spawning and feeding fish, and turbidity controls.

A list of shore needs could be derived which would reflect the type of shore preferred for the preservation and enhancement of marine life in a key fishery area. How extensively one pursues these approaches depends on the overall importance of marine life in the planning area and the ability of marine biologists to define the relationships even in a gross way. It depends, too, on whether they can forecast consequences of alternative courses of action.

3.2.8 Non-Living Resources

If the general demand in the planning subarea is very high and inland sources are scarce, an inventory of off-shore minerals and other non-living resources may be justified. For example, increasing shortages of sand and gravel for construction and beach nourishment may be projected in some locations, especially where a beach provides natural protection to the upland area from erosion and storm and flooding damages.

The uplands can include dunes or bluffs. Dunes are intolerant of human use and erodible bluffs are subject to severe damage from storms and winds. As a consequence no developments should be permitted on the primary dunes and erodible bluffs unless these reaches are protected by wide stable beaches.

Bays are shallow water areas which are extremely productive and are the breeding grounds of important fish and wildlife. Marshes and embayments are the most highly productive areas in the coastal zone.

The resolution of complex coastal zone problems is extremely difficult, but if we accept the simple proposition that shorelands are a unique and valuable resource, many apparently difficult problems present ready resolution. The following guidelines are used to formulate a framework program for the shorelands of the Great Lakes.

Dunes are unique shore form and their protection is in the public interest. Dunes and dune grasses cannot tolerate man and should be protected.

Beaches are dependent upon a source of sand. Littoral drift must be maintained and enhanced. Littoral drift is now being interrupted by navigation structures and shore protection structures.

3.2.9 Other Needs and Problems

Many other relationships can be translated into shoreland needs: historic site preservation, acquisition of public access points, wetlands acquisition, removal of waterfront blight, and unplanned development. Shoreland problems include shoreland alterations, nonessential and conflicting uses, erosion, and sedimentation.

3.2.9.1 Historic Preservation

The existing inventory of historic sites along the Great Lakes shorelands is incomplete. There is also a lack of priorities for preservation of historic sites, perhaps because until very recently there has been little citizen support of historic preservation. Fortunately there are sites around the Great Lakes that could be saved with a change in attitude, but there is no major program for this at present.

3.2.9.2 Public Access Points

Approximately 83 percent of Great Lakes mainland shore is privately owned. Although the current value of shoreland property ranges from $100 to $400 per front foot, acquiring continuous long stretches of shore property could run well in excess of these costs because raising public acquisition funds is extremely difficult and often takes considerable time. In the meantime, property values continue to rise. Also, shoreland property has an extremely high personal value to individual owners, which makes them reluctant to sell at any price.

3.2.9.3 Encroachment on Wetlands

A major portion of Great Lakes marshlands has been filled in the past. In spite of the recognition of the value of marshlands for wildlife habitat, some remaining wetlands are being filled because of their proximity to heavily populated areas. Even in remote areas there are pressures to alter the natural characteristics of marshes. They are being used by recreational boats and are being filled for marinas and residential development.

Much marshland above ordinary high water mark is privately owned. While people are becoming more aware of the value of wetlands, adequate incentives, whether monetary or other, are not available to encourage private land owners to preserve wetlands. Below the ordinary high water mark there are State and Federal regulations to control dredging and filling, but enforcement is a problem.

3.2.9.4 Waterfront Blight

Waterfront blight results from changes in navigation technology, abandonment of shoreland structures, and from shifts from high value to low value property uses. This problem also results from private efforts to control shore erosion by dumping tires, dead trees, and old building materials on beaches and bluffs to act as shore protection. Litter from careless disposal of waste materials along the shorelands contributes to this problem. There are laws and legislation to guard against waterfront blight, but enforcement is a problem.

3.2.9.5 Nonessential and Conflicting Uses

Commercial and industrial development not dependent on shore locations was prevalent along the Great Lakes shorelands in the past. Now some development that was dependent upon water has shifted to nondependent uses such as parking, transportation, and stockpiling. Conflicts are most common in heavily populated and industrial areas. The Great Lakes Region has some 3,270 miles of mainland shoreline so that conflicts and nonessential uses are not as acute as in concentrated areas elsewhere in the nation.

The more difficult conflicting use problems along the Great Lakes shoreland are those which are dependent on use of the same resources while being naturally exclusive, e.g., fishing vs. boating, hunting vs. nature appreciation, and solitude vs. intensive uses. The general public is becoming more aware of the need for compromise in shoreland uses. Unlimited use is not compatible with preservation of shoreland resources.

3.2.9.6 Sedimentation

Tributary stream sediments discharged into the Great Lakes are a major source of shoreland turbidity. Sediment loading caused by natural streambank erosion is difficult to control and requires alteration of natural stream characteristics, but most erosion in the Great Lakes drainage area is accelerated by man's activities and is controllable to a degree. Wave erosion along shorelands composed of heavy soils contributes great amounts of sediment during periods of high water. This is particularly true of the red clay areas of Lake Superior, lower Lake Huron, and Lake Erie. Bank erosion caused by sluffing of bank tops due to frost and precipitation also contributes to the sedimentation problem along certain reaches of the Great Lakes. It is the finer sediment particles, which do not readily settle out, that cause the sedimentation problems along the Great Lakes shorelands. The coarser materials are very desirable as a source of beach building material.

There is a need for land use and development regulation to reduce the amount of sediment from developments entering tributary streams and washing directly into the Great Lakes. There is also a need for additional shore protection works, particularly on privately owned property to control sediment due to wave erosion. However, extensive protection of the shore also reduces the potential source of coarse grained beach building materials necessary to supply downdrift beaches.

3.2.9.7 Unplanned Development

Eighty-three percent of the Great Lakes shorelands is privately owned. Good shoreland management of these shorelands is not yet common at any level of government, but Michigan, Minnesota, and Wisconsin in recent years have enacted shoreland management legislation, which, if enforced, could substantially reduce the unplanned development problem in these States. In addition, passage of comprehensive Federal land use policy legislation is expected in the near future. Section 1 of this appendix suggests a planning framework, including planning guidelines, for the Great Lakes shorelands in an effort to reduce this unplanned development problem.

3.2.10 Extent of Problems

Figure 12–16 illustrates the extent of shoreland problems along a typical reach of Lake Michigan shore in Michigan. A similar detailed inventory of the extent of the problems along the remainder of the Great Lakes shorelands has not been made but should be at an early date. Such an inventory was beyond the funding and manpower capabilities of the Shore Use and Erosion Work Group.

The work group's attempt to identify the most critical shore types and the lakes and connecting waterways with the greatest number of problems appears in Table 12–6. The classifications are based on subjective decisions. Shore types presenting the greatest problems are artificial fills, erodible low bluffs, erodible low plains, and wetlands. Shore types generally having the least problems are the nonerodible types. The portions of the Great Lakes having the greatest problems are Lake Michigan, the St. Clair River, Lake St. Clair, the Detroit River system, and Lake Erie. Available solutions to the problems are shown in Table 12–7.

3.3 Techniques for Achieving Objectives

Both engineering and management techniques are used to achieve objectives. All possible means of satisfying needs and solving problems were grouped into five general program components:

(1) shoreland management
(2) land acquisition and zoning
(3) flood and erosion damage reduction
(4) public policy inducements
(5) legal aspects

The program for satisfying needs suggested here is based on use as presented in the resource appendixes. The mix of program components results from applying professional judgment and experience in such areas as physical capability, economic feasibility, compatibility, and public acceptance. The program recognizes that unique environmental features should be preserved.

3.3.1 Shoreland Management

Land management, including set-back zoning (see Subsection 1.2.7), cover planting, and land-use planning, will satisfy many shoreland needs and problems.

The construction of subdivisions, new highways, and industrial developments without protection or proper set-backs subjects many acres of development to erosion.

Privately and publicly owned forest lands require proper land treatment. Ground cover can be effective in reducing erosion. Proper land management includes provision for wildlife habitat. Multiple-purpose shore use of forest lands should be encouraged.

Land-use planning recognizes the need for recreation, fish and wildlife preservation and enhancement, aesthetic and cultural values, and scenic vistas. Each of these uses has a particular requirement from a management viewpoint. The public and the landowner should be aware of these nonmarket values and be encouraged to preserve them. Good land management generally meets all plan-

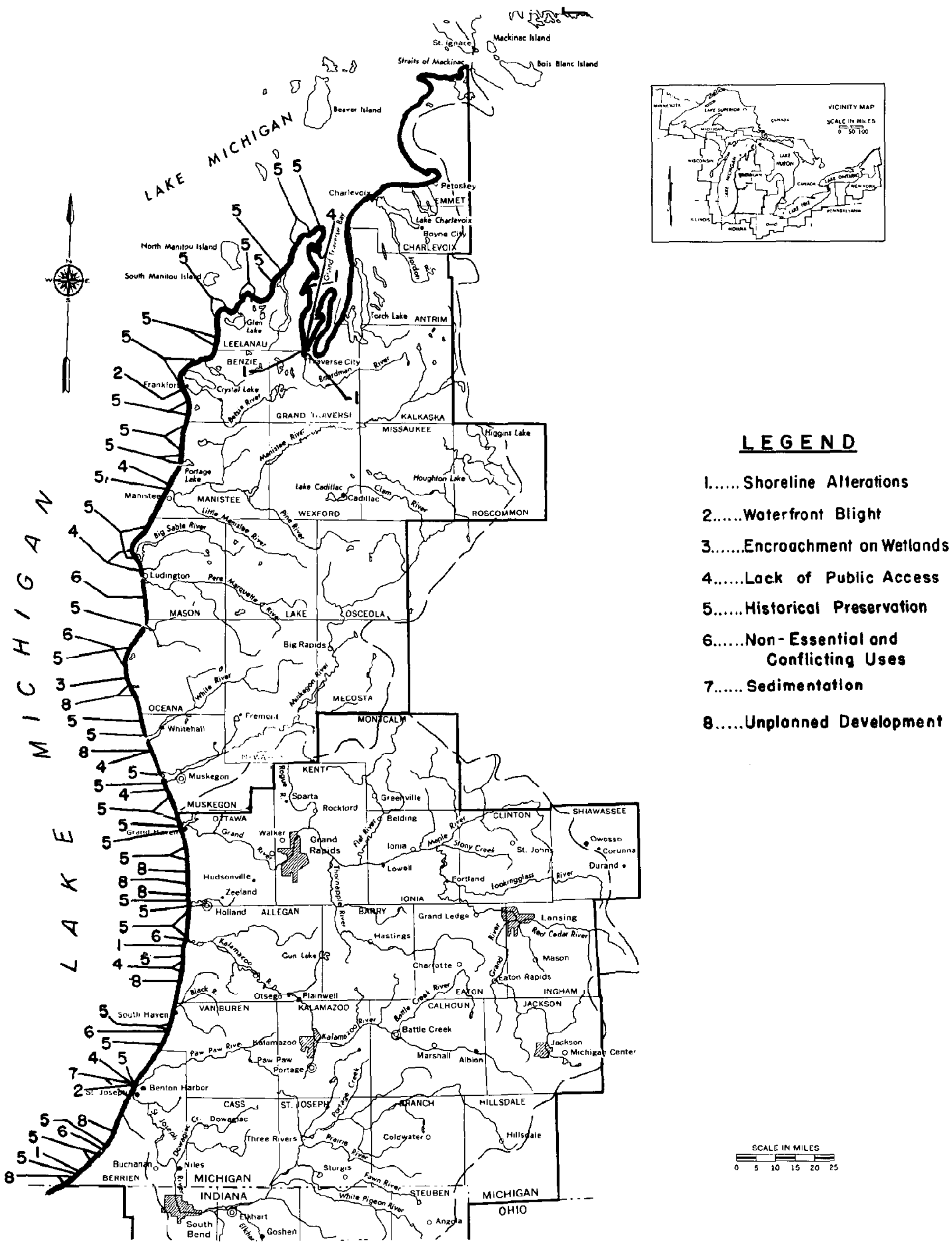

FIGURE 12–16 Great Lakes Shoreland Management Problems

TABLE 12-6 Extent of Shoreland Management Problems

	Shoreline Alterations	Waterfront Blight	Encroachments on Wetlands	Lack of Public Access	Historic Preservation	Non-Essential & Conflicting Uses	Sedimentation	Unplanned Development
Shore Type								
Artificial fill area	Extensive	Extensive	N/A	Uncommon	N/A	Extensive	Rare	Rare
Erodible high bluff	Rare	Common	N/A	Extensive	N/A	Uncommon	Extensive	Common
Non-erodible high bluff	Very rare	Rare	N/A	Uncommon	N/A	Uncommon	Rare	Rare
Erodible low bluff	Uncommon	Common	N/A	Common	N/A	Very common	Extensive	Rare
Non-erodible low bluff	Rare	Uncommon	N/A	Uncommon	N/A	Uncommon	Rare	Uncommon
High sand dune	Very rare	Rare	N/A	Common	N/A	Common	Uncommon	Very common
Low sand dune	Uncommon	Common	N/A	Uncommon	N/A	Very common	Uncommon	Very common
Erodible low plain	Common	Extensive	N/A	Uncommon	N/A	Very common	Common	Very common
Non-erodible low plain	Uncommon	Rare	N/A	Uncommon	N/A	Uncommon	Rare	Very common
Wetlands	Extensive	Common	Extensive	Rare	N/A	Extensive	N/A	Common (in past)
Lake or Connecting Waterway								
Lake Superior	Minimal	Minimal	Minimal	Minimal	Significant	Minimal	Mod. (W. end)	Minimal
St. Marys River	Significant	Minimal	Minimal	Minimal	Significant	Minimal	Moderate	Minimal
Lake Michigan	Moderate	Moderate	Minimal	Moderate	Significant	Mod. (S. 1/2)	Moderate	Moderate
Lake Huron	Minimal	Minimal	Minimal	Moderate	Significant	Minimal	Moderate	Minimal
St. Clair River, Lake St. Clair & Detroit R.	Significant	Significant	Significant	Moderate-Significant	Significant	Significant	Moderate-Significant	Significant
Lake Erie	Moderate	Moderate	Moderate	Significant	Moderate-Significant	Moderate	Significant	Moderate

N/A: not applicable

TABLE 12-7 Available Solutions to Shore Management Problems

	Shoreline Alterations	Waterfront Blight	Encroachments on Wetlands	Lack of Public Access	Historic Preservation	Non-Essential & Conflicting Uses	Sedimentation	Unplanned Development
Federal								
Agriculture	------	------	------	------	------	------	Land treatment program	Planning assistance on agricultural lands
Army	Permits	Permit removal authority	Permits	Construction projects	------	Permits	Dredging permits, construction programs	------
Interior	------	------	------	Purchase power condemnation, grants	Purchase	Planning requirements	Construction Programs	------
HUD	------	------	------	Purchase grants	------	Planning requirements	------	Planning fund grants
Great Lakes Basin States	Permits	Permit removal clause	Permits, bulkhead lines, state trespass laws	Purchase, easement, lease, condemnation, accept donated property	Transfer of surplus Federal property, purchase, restoration	------	Permits, planning, construction, regulation	Planning grant assistance
Local	Bulkhead lines, zoning, permits, etc.	Purchase, condemnation, urban renewal, health & safety regulations	------	Purchase, condemnation, zone	Purchase, zone, restoration	Local building codes and ordinances	Permits, zoning	Enforcement through zoning, building codes
Citizen	------	------	Group action purchase	Group action purchase, donate	Group action, purchase, donate	------	Citizen education	------

ning objectives. Monetary investments in land treatment return both market and non-market dividends.

The scarcity of shoreland requires management for its best use. Environmental quality can be maintained and improved if land use properly recognizes land values.

The U.S. Department of Housing and Urban Development can provide funds for shoreland management studies under their 701 program. The Corps of Engineers may provide some assistance in documenting historic shoreland erosion in connection with their flood plain information studies. General authority for making erosion rate studies is needed, however. The Soil Conservation Service, Department of Agriculture, can provide assistance on cover planting for shoreland areas.

3.3.2 Land Acquisition

Outright acquisition of those lands with important environmental, historical, or recreational features that should be reserved for public use on a long-term basis, should be considered.

Mismanaged forest lands could be purchased and brought under public control for multiple use. There could be added benefit from some shorelands subject to erosion if they were brought under public control and treated. Recreation areas, hunting areas, aesthetic and cultural areas, wild and scenic rivers, natural wetlands, and reclaimed mining lands are part of this program component.

The land acquisition program is considered a partnership arrangement between non-Federal and Federal interests. States could show the way by purchasing eroded shorelands and existing forest land, and counties, cities, and conservation districts could follow by purchasing such lands for public use.

Federal grant-in-aid programs to purchase lands or secure easements now exist in the Bureau of Outdoor Recreation, the Bureau of Sport Fisheries and Wildlife, and the National Park Service. Lands may also be purchased outright by the Federal government to serve current Federal projects. National forests would benefit by the acquisition of land within the proclaimed boundary to consolidate land holdings and improve management efficiencies.

The high cost of the shorelands from $75 to more than $400 per front foot for outright purchase, precludes the outright purchase of long reaches of shoreline areas.

Land acquisition should be directed toward meeting all planning objectives. Outstanding areas should be acquired for their national or regional importance, with the emphasis on environmental enhancement. The environment would be best served by the retention of suitable lands for the long-term enjoyment of Basin residents.

3.3.3 Flood and Erosion Damage Reduction

The program component for reducing flood and erosion damages has been divided into preventive and corrective features. The first to be considered are the non-structural measures that lessen flood and erosion losses.

Preventive policy begins with identifying the flood and erosion area and the actions that can be taken to reduce further damages. The property owner, the potential buyer, and the lender should be made aware of the hazards. Preventive means of reducing potential flood and erosion damages or distributing the losses include:

(1) flood plain and erosion zoning ordinances and subdivision regulations
(2) building codes and health regulations
(3) development of open-space policies
(4) tax adjustments on flood- and erosion-prone shorelands
(5) posting of warning signs
(6) flood insurance on flood plain properties
(7) public purchase and easements for flood- and erosion-prone lands

The preventive means would be applied to those urban and rural areas where such measures are the best means of land management. Particular areas that should be considered are undeveloped shorelands shown on the shoreland maps for each plan area. Flood plain information and erosion hazard studies should be undertaken for these areas. Responsible public officials should be aware of the flood and erosion hazard in each area.

The responsibility for initiating preventive means lies with the States, responsible local government agencies, and private property owners. Some States already require flood plain erosion zoning and regulation, and others may choose to make local government organizations responsible. The Federal government can assist government organizations by providing information on the delineation of the flood plain and the severity and frequency of the floods, but it does not have authority to make erosion rate studies.

The Department of Housing and Urban Development can issue flood insurance under the Flood Insurance Act of 1968. Flood insurance does not reduce losses, but it eases the financial impact. In order to qualify for flood insurance, future flood plain development must be regulated. Tax adjustments might also be used to ease the financial loss. This program does not cover shorelands subject to erosion.

Private property owners and local public officials should be informed of flood hazards and encouraged to use the land accordingly. New structures might be flood-proofed, or flood- and erosion-prone property might be used for purposes that are not severely affected by damages. Public acquisition of flood- and erosion-prone lands should be considered for recreational developments and fish and wildlife, expecially in and near urban areas.

The program component for corrective means of reducing flood and erosion damages consists of reduction of lake levels, construction of local protection structures, and beach restoration and nourishment. Corrective means of reducing flooding damages are:

(1) lake regulation works
(2) sheet pile bulkheads
(3) concrete curved-face seawalls
(4) riprap revetments
(5) steel sheet pile breakwaters
(6) rubble-mound breakwaters
(7) offshore breakwaters
(8) beach nourishment
(9) groins

Each type of protective measure has its own inherent function, advantage, and disadvantage, as presented in Section 2. The Corps of Engineers can help build emergency protective works when flooding is imminent, and some States can provide flood control works. Local government organizations such as conservancy or flood control districts and private individuals can also choose to protect their property by corrective works. The Corps of Engineers can plan, design, construct, and operate general-use flood control works with State and local government units. Erosion control structures can also be planned, designed, and constructed by the Corps of Engineers on public or private shorelands that provide opportunity for public use. Since more than 80 percent of the shoreline subject to erosion is privately owned, little can be done under the current national program for erosion control centered on public benefits.

Application of the flood and erosion reduction program component could serve all objectives. The environmental objective would be best served by a regional program of beach stabilization using offshore sand deposits, but the national income objective may be adversely affected because tangible benefits from this protection may not exceed tangible costs.

3.3.4 Public Policy Inducements

Shore objectives can often be satisfied by public policies that indirectly influence the way people use shore property. Major policies in this type relate to property taxes and cost-sharing. See Subsection 1.4.1.2 for tax inducements.

Almost all shoreland communities employ property taxes to provide funds for their services. When property taxes are tied to the best use of land under a zoning system, property owners will be induced to develop their land up to this level or sell to someone who will. If property tax levels are tied to actual use, property owners will feel less pressure to develop. To encourage special use and actions critical to a master plan, preferential tax levels can be levied and taxes can be deferred or waived. While methods such as these are employed to preserve open space or encourage conservation measures, they also encourage the speculative holding of land. For example, an owner might willingly cooperate with a plan for a green belt area around a city by keeping his land in essentially tax-free pasturage until urban development in the vicinity raises the market value of his holdings to an irresistible level. The deferment or waiver of taxes on wetlands may not have a great inducement effect since wetlands are usually taxed at a very low rate.

Cost-sharing can be a very effective inducement to meet some shore objectives. Three principles of cost-sharing are widespread benefits, indivisibilities, and user charges. When the benefits of a proposed action, such as beach acquisition or public development, are judged to be sufficiently widespread, higher levels of government often recognize a responsibility to share the cost under various formulas. When an action, such as restoring a long reach of beach as a whole or acquiring an ecological preserve, must be performed in concert or not at all (an indivisibility), the cost must be shared somehow. When benefits can be pinpointed, user charges should be considered, but the administrative cost of collecting these charges often eats up most of the revenues gained. In return for sharing the cost, higher levels of government frequently exact binding agreements to assure that the benefits are indeed widespread. Federal contribution to shore protection projects is heavily influenced by the degree of public access and use. Federal cost-sharing policies for these projects are explained in Section 4.

Special authorizing legislation is necessary for corrective shore protection works. Attempts to force a shoreline property owner to take measures at his own expense to protect his shoreline might be unconstitutional. Certainly, it would be a sharp departure from existing practices. It is difficult to find ways of charging private property owners for the benefits they derive from the government's shoreline protection and enhancement measures.

3.3.5 Legal Aspects

Some legal aspects have already been discussed in Subsection 1.4.

3.4 Formulating a Shore Plan

The tentative objectives that have survived the initial feasibility test implicit in the evaluation of alternative courses of action must now be integrated into a time and money schedule specifying who does what, and when, where, and how it is done. Funding procedures that have been used in the past are examined and applied. Institutions, agencies, managerial techniques, and engineering projects should be integrated into a time-phased program as available political channels are employed to obtain appropriate assistance in promoting the program and enacting any necessary legislation.

3.5 Implementing the Plan

In implementing the plan, knowledge gained from unexpected developments—favorable and unfavorable—is channeled back through the continuing planning-implementation cycle. Comprehensive planning in shore management must deal with the reality that actions taken have internal and external impact repercussions. At no time will the world become obligingly static, making further planning unnecessary, so an essential element of the program is keeping interested people informed.

Section 4

AGENCY PROGRAMS FOR SHORELAND DAMAGE PREVENTION

4.1 Federal Legislation

The Coastal Zone Management Act of October 1972 authorizes the Secretary of Commerce to make annual grants to coastal States to assist in the development of a management program for the land and water of their coastal zone. The current Federal policy for management of the Great Lakes shoreland resources is contained in Section 303, Public Law 92–583, Title III—Management of the Coastal Zone, which states:

> it is the national policy (a) to preserve, protect, develop, and where possible, to restore or enhance, the resources of the Nation's coastal zone for this and succeeding generations, (b) to encourage and assist the states to exercise effectively their responsibilities in the coastal zone through the development and implementation of management programs to achieve wise use of the land and water resources of the coastal zone giving full consideration to ecological, cultural, historic, and esthetic values as well as to needs for economic development, (c) for all Federal agencies engaged in programs affecting the coastal zone to cooperate and participate with state and local governments and regional agencies in effectuating the purposes of this title, and (d) to encourage the participation of the public, of Federal, state, and local governments and of regional agencies in the development of coastal zone management programs. With respect to implementation of such management programs, it is the national policy to encourage cooperation among the various state and regional agencies including establishment of interstate and regional agreements, cooperative procedures, and joint action particularly regarding environmental problems.

Authority for the design and construction of erosion control works to protect shoreline resources is contained in Public Law 727, 79th Congress, which states:

> To prevent damage to the shores of the United States, its territories and possessions, and encourage healthful recreation of the people, it is the policy of the United States, subject to the provisions of this Act, to assist in the construction, but not the maintenance, of works for the restoration and protection against waves and currents of the shores of the United States, its territories and possessions.

The two stated purposes of the current Federal shore protection program are to prevent shore damage, and to promote recreation. The criteria for Federal assistance, public use, and public benefit, are also covered in the act. To obtain Federal assistance in project construction, a study must first be made by the Corps of Engineers and the protection plan must be economically justified and authorized by Congress. An exception to this is that eligible projects with a Federal share of the cost not exceeding $1,000,000 can be authorized by the Secretary of the Army.

4.2 Federal Programs

A number of Federal agencies are involved directly or indirectly in the development of shoreland resources.

4.2.1 Agriculture

The Soil Conservation Service can suggest vegetation or structures to combat shore erosion. The Service also makes soil surveys, which provide a basic inventory of the soils in an area, that are useful in identifying high risk and areas with ecological importance which need protection or regulation. The Forest Service manages national forests. Most of the shore it manages is undeveloped, with swimming being the principal use. On those sites where intensive use is planned, developments are set back from the shoreline to protect the site.

4.2.2 Army

The Corps of Engineers is involved in the entire field of water resources development including extensive shoreland-related activities. These activities include measures for reduction of shoreland erosion and flooding, construction of facilities for both commercial and recreational navigation, and the issuance of permits for docks and other physical structures in navigable waters.

The authority and scope of Federal responsibility and participation in shore protection and beach restoration has been developed through a series of River and Harbor Acts beginning with the Act of July 3, 1930. The Corps of Engineers has been assigned the major responsibility for shore erosion control at the Federal level, and under existing legislative authorities, it researches the causes of beach erosion, investigates and studies specific beach erosion problems, and constructs (or in certain cases, reimburses local and State governments for constructing) shore protection and beach restoration projects.

Federal cost sharing in shore protection projects is generally limited to publicly owned lands. As much as 70 percent of the cost of protecting publicly owned shores may come from Federal funds if certain conservation, development, and use requirements are satisfied. Projects not meeting these requirements may still be as much as 50 percent Federally funded. Federal involvement in the protection of private property is possible if such protection is incidental to the protection of publicly owned shores, or if such protection would result in public benefits. Measures to mitigate erosion damage attributable to Federal navigation works can be constructed entirely at Federal expense, whether property affected is publicly or privately owned.

Shore protection and beach erosion projects begin with a local request for assistance. Subsequently a feasibility study of the erosion problem is undertaken, followed by project authorization, funding, and construction. Studies and projects may be completed under one of the following two programs.

Regular project programs are studies and projects specifically and individually authorized and funded by Congress with no limit on the Federal share of the cost of construction. Authorization to undertake a study is granted by a resolution approved by the Public Works Committee of either the Senate or House of Representatives. Occasionally it is included in a River and Harbor Act adopted by Congress and approved by the President.

Studies and projects for which individual authorization by Congress is not required generally are undertaken at the discretion of the Chief of Engineers under the continuing authority of Section 103 of the 1962 River and Harbor Act, as amended. This is known as the small projects program. The Federal cost of construction is limited to not more than $1 million. A study is initiated upon request of a responsible local public agency.

In addition to the above programs, Section 111 of the 1968 River and Harbor Act authorizes the Secretary of the Army, acting through the Chief of Engineers, to investigate, study, and construct projects for the prevention or mitigation of shore damages attributable to Federal navigation works. The cost of installing, operating, and maintaining such projects is borne entirely by the United States. Such projects cannot be constructed without specific authorization by Congress if the estimated first cost exceeds $1,000,000. A study under this authority is initiated upon request of a responsible local public agency to investigate a particular navigation structure.

Studies undertaken at Federal expense determine whether a Federal project is justified and, if so, whether its construction is feasible. All projects constructed under the regular or small project programs must be sponsored by a local public agency legally empowered and financially capable of cooperating with the United States. Generally, the sponsor must:

(1) contribute from 30 to 50 percent of the first cost of construction in cash

(2) provide all necessary lands, easements, and rights-of-way

(3) hold and save the United States free from claims for damages

(4) prevent water pollution, which would affect the health of bathers

(5) maintain the completed project

(6) assure continued public use of the protected area

Authority for Federal emergency assistance in flood and coastal storm situations is set forth in Public Law 99/84, as amended by Section 206 of the Flood Control Act approved October 23, 1962, and by Section 9 of the Flood Control Act approved June 15, 1936. Preceding and during flood and coastal emergencies, the Corps of Engineers, according to statutory authorities assigned to the Chief of Engineers, must:

(1) preserve Federally owned and maintained flood control works and other facilities operated by the Corps of Engineers

(2) furnish appropriate technical assistance to State and local authorities upon request, advising them in their efforts to maintain the integrity of flood control works and Federally authorized shore and hurricane protection projects under their jurisdiction

(3) if responsible State or local authorities are unable to cope with the flood or coastal storm situation, give direct Federal assistance either by supplying needed materials and equipment or by undertaking Federal flood fighting or emergency protection

Federal and State permits are required

prior to the construction of any work in, under, across, or on the banks of navigable waters of the United States. In general, both Federal and State permits are required prior to the initiation of construction of shore protection structures along the shores of the Great Lakes, lakeward of the high-water mark. Federal permits are issued by the Corps of Engineers, usually only after a State permit has been obtained. Permits for structures in navigable waters will be reviewed for compliance with the authorities and requirements of the Federal Water Pollution Control Act Amendments of 1972, the Marine Protection Research and Sanctuaries Act of 1972, and the Coastal Zone Management Act of 1972.

4.2.3 Commerce

The Maritime Administration is responsible for training, research, development, promotion, and financial assistance for water shipping operations, and construction. It has responsibilities for promoting the development of ports and related waterway transportation facilities.

The Lake Survey Center is concerned with the preparation of Great Lakes navigation charts and with the study of all matters affecting the hydraulics and hydrology of the Great Lakes.

The Economic Development Administration has programs that provide technical and financial assistance to designated areas and regions having persistent underemployment problems. Public works grants, loans, and loan guarantees are available to help improve economic conditions.

4.2.4 Environmental Protection Agency

The Great Lakes Water Quality Agreement of 1972 between the United States and Canada includes a reference to a study of pollution of the Great Lakes resulting from land drainage and erosion. It is to be a cooperative study between United States and Canadian Federal and Provincial governments. The Environmental Protection Agency will play a significant role in determining the effect of land drainage on the water quality of the Great Lakes, and it will also decide what remedial programs can be established to eliminate or reduce pollution from the source.

The Federal Water Pollution Control Act, Amendments of 1972, Section 108(a) authorizes EPA to establish grants to States and local governments in order to demonstrate new methods and techniques and develop preliminary plans for the elimination or control of pollution of the Great Lakes. Several projects are now in progress.

4.2.5 Housing and Urban Development

The main concern of the Department of Housing and Urban Development is with housing and urban problems. It administers programs offering local communities financial assistance for a wide array of matters, including comprehensive planning for the acquisition and development of open space and recreation facilities, for urban renewal projects, docks, and other improvements. It can also assist in identifying flood hazards and may declare cooperating communities eligible for the federally subsidized National Flood Insurance Program, if adequate flood delineations and legal requirements concerning flood plain management are met.

The Federal Disaster Assistance Administration (FDAA, formerly OEP) within the Department of Housing and Urban Development is responsible for the management of Federal disaster assistance including the administration of the President's Disaster Fund, coordination of Federal agencies' relief and recovery assistance, and supervision of disaster preparedness research and planning. The President retains the authority to declare "major disasters," making the area eligible for aid.

4.2.6 Interior

The Bureau of Outdoor Recreation has major responsibilities for outdoor recreation planning, research, coordination of Federal outdoor recreation activities, and financial and technical assistance to States and communities. The Bureau administers the Land and Water Conservation Fund, which provides financial assistance to States and through States to local public agencies for the acquisition and development of outdoor recreation resources.

The National Park Service plans and administers the natural, historical, and recreational areas in the National Park System. One such area is the Indiana Dunes National Lakeshore between Gary and Michigan City, Indiana.

The Bureau of Sport Fisheries and Wildlife has active programs in the Great Lakes involving Federal aid for fish hatcheries, management and enforcement, wildlife refuges, and wildlife enhancement. The Bureau is heavily involved with Great Lakes fish stocking operations.

The Geological Survey is concerned with the collection and analysis of basic data on water resources. In addition, the Survey is responsible for the preparation of topographic maps of the entire country. Such maps have been prepared for more than 90 percent of the Great Lakes Basin.

4.2.7 Small Business Administration

The Small Business Administration can provide low interest physical disaster loans to victims of disasters to restore their damaged property. Loan funds may be used to repair or replace damaged or destroyed real estate, machinery, equipment, household items, and other personal property. Individuals, business concerns, churches, schools, and hospitals are eligible to apply for assistance.

4.2.8 Transportation

The Coast Guard's major peacetime role centers on shipping safety on the Great Lakes. Vessels and men are stationed at strategic points throughout the Great Lakes. Icebreakers are employed to assist early and late season shipping.

4.3 State Programs

Although each State expresses a different degree of interest in the shoreline, depending on its resources and problems, they have adequate authority to manage shoreland resources if their individual authorities are effectively coordinated. Three states, Michigan, Minnesota, and Wisconsin, have shoreland management programs (Table 12–8).

4.3.1 Illinois

Efforts have been limited to categorical programs such as development of parks and prevention of beach erosion.

4.3.2 Indiana

Indiana has no program or plan in effect.

4.3.3 Michigan

The Shorelands Management and Protection Act of 1970 was enacted to protect high-risk erosion areas and environmental areas necessary for the preservation and maintenance of fish and wildlife. The act gives local governments authority to institute required zoning regulations. The State policy is to maximize the acquisition of shore areas for public use.

4.3.4 Minnesota

Minnesota's shoreline management law, which was enacted in 1969, requires all counties to establish land-use controls for shorelands in unincorporated areas. The act's primary purpose was to protect the shores of inland lakes, but areas along Lake Superior are also covered. Local governments have authority to institute the required zoning regulations within a specific time period.

4.3.5 New York

In 1960 New York was granted power of eminent domain for wetlands acquisition. A bill was passed in 1969 creating the Division of Marine and Coastal Resources, which is responsible for managing the State's coastal resources activities. A major land-use inventory, which could have an impact on shoreland management, was undertaken.

4.3.6 Ohio

In Ohio a comprehensive study of coastal zone needs and resources was begun in June 1972 by the Department of Natural Resources. The study is seen as the initial step in a broad shorelands program.

4.3.7 Pennsylvania

Pennsylvania's shoreland management efforts have been limited to programs such as park development and beach erosion prevention. The State has focused on protection for

TABLE 12–8 Shoreland Management Programs of Michigan, Minnesota, and Wisconsin

	Michigan	Minnesota	Wisconsin
Legislative authority	Shorelands Protection and Management Act of 1970.	Chapter 777, Laws of Minnesota 1969.	Wisconsin Water Resources Act of 1965.
Great Lakes shoreland definition	Land, water, and land beneath the water which is in close proximity to the shoreline. Lands to be regulated for erosion control lies between lines 1,000 feet lakeward and 1,000 feet landward of the ordinary high water mark.	Land located within 1,000 feet from the normal high water mark.	Land located within 1,000 feet from the normal high water mark.
Jurisdiction	Local units of government to enact and enforce regulations. State to complete engineering and environmental studies as a basis for local enforcement. State to establish setback lines sufficient to accommodate loss of land based on 30-year economic life of structures. If local units fail to act, State will regulate undeveloped lands to prevent erosion damage.	Counties to enact and enforce zoning ordinances for unincorporated areas. State to establish minimum standards and to insure zoning is accomplished by counties.	Counties to enact and enforce zoning ordinances for unincorporated areas. State to establish minimum standards and to insure zoning is accomplished by counties.
Management objectives	1. Provide for protection, effective management of the quality of the Great Lakes shorelands. 2. Requires regulation of high risk erosion and environmental areas. 3. Complete engineering and environmental studies to identify high risk areas. 4. Develop a comprehensive plan for the use and development of all shorelands.	1. Preserve and enhance the quality of surface waters. 2. Conserve the economic and natural environmental values of shorelands. 3. Provide for wise utilization of water and related land resources.	1. Maintain safe and healthful conditions. 2. Prevent and control water pollution. 3. Protect spawning grounds fish and aquatic life. 4. Control building sites, placement of structures and land uses. 5. Preserve shore cover and natural beauty.
Shoreland regulation standards and criteria to be established	1. Procedures for resolving conflicts in multiple use of shorelands. 2. Criteria for widest variety of beneficial uses. 3. Enforcement powers to assure compliance with management plans and to resolve conflicts in uses. 4. Criteria for protection from erosion and flooding, for aquatic recreation, for shore cover for low lying lands and fish and game management. 5. Criteria for land use regulations including shoreland layout for residential, industrial and commercial development, shoreline alteration control and building setback line based upon 30-year economic life of structures. 6. Provide for prevention of shoreland littering, blight, harbor development, and pollution. 7. Criteria for regulation of mineral exploration and production. 8. Provide basis for necessary future legislation pertaining to effective shoreland management.	1. System of classification of public waters. 2. Subdivision regulations. 3. Land use regulations, including minimum lot sizes for building sites; placement of structures in relation to shorelines and roads, and alteration and preservation of the natural landscape. 4. Regulations governing the type and placement of sanitary facilities. 5. Criteria for variances from minimum standards.	1. Appropriate shoreland management districts 2. Subdivision regulations. 3. Land use regulations, including minimum lot sizes, setback requirements for buildings and structures, regulations of tree and shrubbery cutting and filling and dredging criteria. 4. Requirements for construction of water supply and waste disposal systems. 5. Administrative and enforcement provisions.
Status of programs	Legislation requires: 1. Completion of engineering study by April 1972 to identify high risk erosion areas and type and cost of protection against erosion needed. 2. Completion of environmental study by April 1972 to identify significant environmental and wetlands and those which should be protected by shoreland zoning. 3. Preparation of a plan for the use and management of the Great Lakes shoreland by October 1972. 4. Local units of government may regulate critical erosion and environmental areas by July 1, 1973. If local units of government fail to so act by April 1, 1974, State can compel.	Legislation requires management ordinances to be adopted July 1, 1972. St. Louis and Cook Counties expected to meet deadline. Lake County expected to comply by end of 1972.	Legislation requires enactment of ordinances by January 1, 1968. Zoning ordinances have been adopted for all counties. Ordinances for counties which have a minimum setback of 75 feet are being upgraded to increase the setback based on estimated long-term erosion rates.

Presque Isle State Park and has also sought to increase public access to shorelands.

4.3.8 Wisconsin

Part of Wisconsin's Water Resources Act of 1965 required counties, assisted by the Department of Natural Resources, to zone all lands in unincorporated shoreland areas. The aim of the program is to protect inland lake shores, but the Act also applies to coastal areas on Lake Superior and Lake Michigan.

4.4 Local Programs

Local units of government have the authority to guide development and use of the shorelands through zoning, building codes, subdivision regulation, land use, and comprehensive planning. In the Great Lakes States it is the responsibility of local shoreland governmental units to enact and implement controls on development in high-risk erosion areas.

4.5 The Private Citizen

The private shore property owner is responsible for protecting the 83 percent of the Great Lakes shoreline that is privately owned. Under present law no help can be expected in evaluating the situation or in protecting private land from erosion damages, and yet individual efforts are ineffective because of inadequate knowledge and lack of coordination.

4.6 Program Assessment

There are a number of reasons why the current Federal programs have not been effective in reducing erosion damages on the Great Lakes. First, studies by the Corps of Engineers reveal that progress under present shore protection policies and programs has been slow. Of the 22 beach erosion control projects authorized by Congress, less than one-half have been constructed. The Corps of Engineers has no authority and no program to construct erosion control projects aimed solely at protecting private shores. Since 83 percent of the shoreline is privately owned, Federal assistance is available to protect only a small portion of shoreline resources.

Second, although a Federal program for planning assistance to the Great Lakes States is included in the Coastal Zone Management Act of 1972, funds were not made available until FY 1974.

Third, the lack of sound institutional arrangements to solve erosion problems undermines sound comprehensive planning for the Great Lakes shorelands. The recently completed Great Lakes Water Level Report to the International Joint Commission indicates that only minor improvements in lake regulation are practical and that the most promising measures to reduce shoreline damages are strict land-use zoning and structural setback requirements. Unfortunately much of the shoreline has already been developed.

The challenge is to organize the interested Federal and State agencies so that they can effectively contribute to the solution of the full range of Great Lakes shoreland problems. A coordinated program is needed for preserving and enhancing shoreland resources for the benefit of the Region and the nation.

Section 5

GREAT LAKES ANALYSIS OF SHORE PROPERTY DAMAGE

5.1 Introduction

Shore property damage resulting from fluctuation in water levels may be caused by inundation, wind-generated waves, or a combination of both. Shore damage varies with the elevation of the still-water level; the temporary increase in that level at a specific location generated by wind or barometric pressure gradient; the duration, magnitude, and frequency of wind-generated waves; the extent of wave run-up on shore; and other factors. Strong winds during a storm cause the water surface of the lake to tilt with the wind, lowering the water level along the upwind shore and raising the levels along the downwind shore. The maximum elevation of the water surface along the downwind shore is termed the storm water level. The maximum vertical distance above the water level to which breaking storm waves rise is called the wave run-up. The ultimate water level at a reach during a storm is the sum of the storm water level plus the wave run-up. The effects of wind and waves on the lake levels are shown schematically on Figure 12–17.

A number of other factors, such as the nature of shore materials, exposure to onshore winds, offshore and onshore slopes, berms, and backshore elevations and widths, affect the ability of the shore to absorb the energy transferred from the surface of the lake. these factors have a continuous effect, which is dramatized during storms. Ice on the Great Lakes damages the shoreline, but the damage usually results from short-period, local conditions rather than from the overall lake regime.

5.1.1 Assumptions and Methodology

A complete survey of the United States shoreline of the Great Lakes and connecting rivers was made during 1966. Since the lake levels were near normal at that time, no significant damage was occurring, and no additional data were collected.

The only consistent shoreline damage information available for the Great Lakes is that compiled in May 1952 by the Corps of Engineers with the assistance of local coordinators from the Great Lakes States. The damage information collected pertained to the highwater period from the spring of 1951 to the spring of 1952. Damages for each Lake were grouped according to property use, property ownership, and cause of damage.

The estimate of total damage to all shore properties during 1951–1952 was $61 million. Wave action alone caused $50 million worth of destruction. Flooding accounted for the other $11 million (Table 12–9). Recurrence of the 1951–52 storms in this Region could cause a minimum of $120 million in property damage. This estimate is based on updated prices and does not include the damages to developments constructed after 1952.

Future damages to the Great Lakes shoreline are directly related to its economic use. Estimated future uses of the shoreline were projected under the following land-use categories: industrial, commercial, utilities, residential, public parks and beaches, fish and wildlife habitat, agricultural, forests, and undeveloped.

To determine future erosion and inundation damages future land use was projected from the land base found in the 1966 field surveys. Agricultural, undeveloped, and forestry uses of the shoreline are expected to yield to urban-oriented residential, recreational, and industrial uses, thereby increasing potential economic damages. However, it is assumed that as property becomes more valuable, it will be protected by structural measures. It is assumed that when damage costs equal the cost of protective works, such works will be constructed.

After future land use was estimated, the length of shoreline in each land-use category susceptible to damages because of lack of natural or artificial protection was identified. Each reach of the Great Lakes was analyzed in terms of its economic potential. The 1980, 2000, and 2020 total potential damage values were determined on the basis of the projected

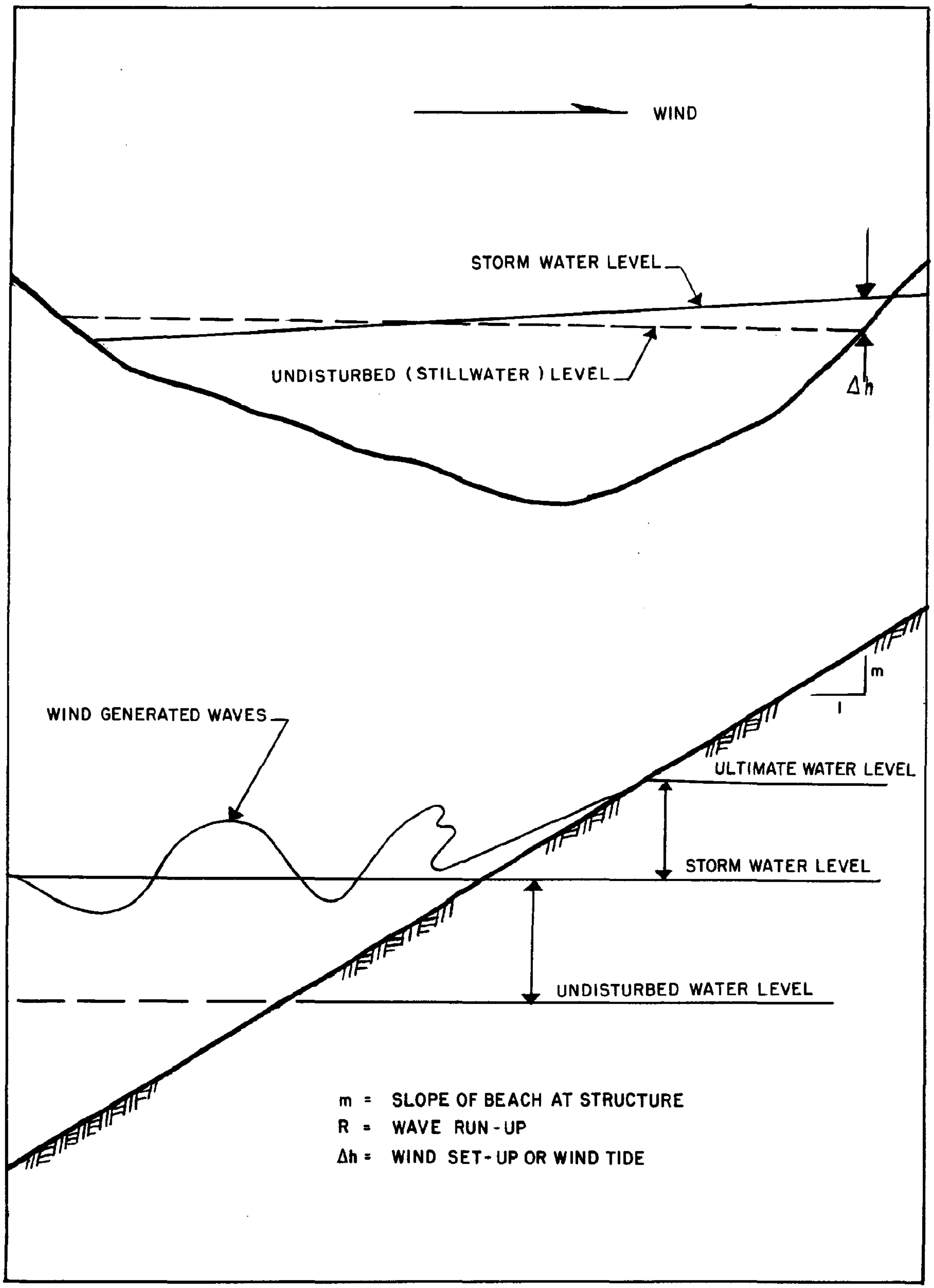

FIGURE 12–17 Storm Effects on Water Levels

TABLE 12–9 Total Damage to Great Lakes Shore Property, One-Year Period, 1951 to 1952 (in 1952 dollars)

State	Superior	Michigan	Huron[a]	Erie	Ontario[b]	Total
Minnesota	1,947,000	----------	---------	----------	---------	1,947,000
Wisconsin	982,000	5,179,000	---------	----------	---------	6,161,000
Illinois	---------	11,288,000	---------	----------	---------	11,288,000
Indiana	---------	5,195,800	---------	----------	---------	5,195,800
Michigan	1,430,000	8,981,000	6,975,800	----------	---------	17,386,800
Ohio	---------	----------	---------	11,299,300	---------	11,299,300
Pennsylvania	---------	----------	---------	448,500	---------	448,500
New York	---------	----------	---------	172,400	6,443,500	6,615,900
Total	4,359,000	30,643,800	6,975,800	11,920,200	6,443,500	60,342,300

[a]Includes St. Marys River below locks, St. Clair River, Lake St. Clair, and Detroit River

[b]St. Lawrence River not included

future land use, protected property, and unit value of property. This general analysis suggests that the recurrence of the 1951–1952 high water and storms would result in a fourfold increase in damages in the year 2020.

5.1.2 Methods of Analysis

Evaluation of single purpose alternative plans for shoreland erosion and flooding problems consists of analyzing the effect of land management measures or local protection projects on total potential damages. The assumption is that the ratio of damage reduction to total damages for a bench mark period is equal to the damages for that year multiplied by both the ratio of existing development to total development and future development to total development of the shoreland for that period.

The shoreland management alternative is based on the assumption that future flood and erosion damages can be prevented by restricting development in the flood plain and high risk erosion areas. Shoreland management measures (Section 3) are the preferred method of accomplishing this. The local protection alternative involves constructing shore protection (Section 2, Coastal Processes and Shore Protection).

5.2 Lake Superior and the St. Marys River

Lake Superior, the largest and northernmost Great Lake, has the most rugged, uninhabited, and inaccessible shorelands of all the Great Lakes (Figure 12–18). Minnesota, Wisconsin, and Michigan all have jurisdiction over portions of Lake Superior's 912 miles of the United States mainland shoreline. The United States mainland shoreline of the St. Marys River, which, for the purpose of this study is considered to be the 91.2 miles from the Soo Locks to its confluence with Lake Huron near De Tour, Michigan, is entirely within the State of Michigan.

Because of the lack of development and the high scenic quality of the Lake Superior shorelands, almost all of the shorelands are considered of prime recreational value. Furthermore, the lack of industrial development and the low population of this northern region leaves the overall water quality of Lake Superior excellent. A few problems exist in isolated areas, primarily as a result of mining activities.

Few metropolitan areas exist along the shorelands of Lake Superior and the St. Marys River. Duluth, Minnesota, is the largest port on the Lake, handling primarily iron ore and related products. Other metropolitan areas of significance include Superior and Ashland, Wisconsin, and Houghton-Hancock, Marquette, and Sault Ste. Marie, Michigan.

The economy of the Lake Superior-St. Marys River region is geared mainly to mining, forestry, and tourism. Copper and iron ore are the main minerals mined in the region, although mining activity, especially copper, has declined in recent years. Other than mining and lumbering very little industry is located along the shorelands. Outside of major urban areas, commercial development is primarily limited to the tourist industry.

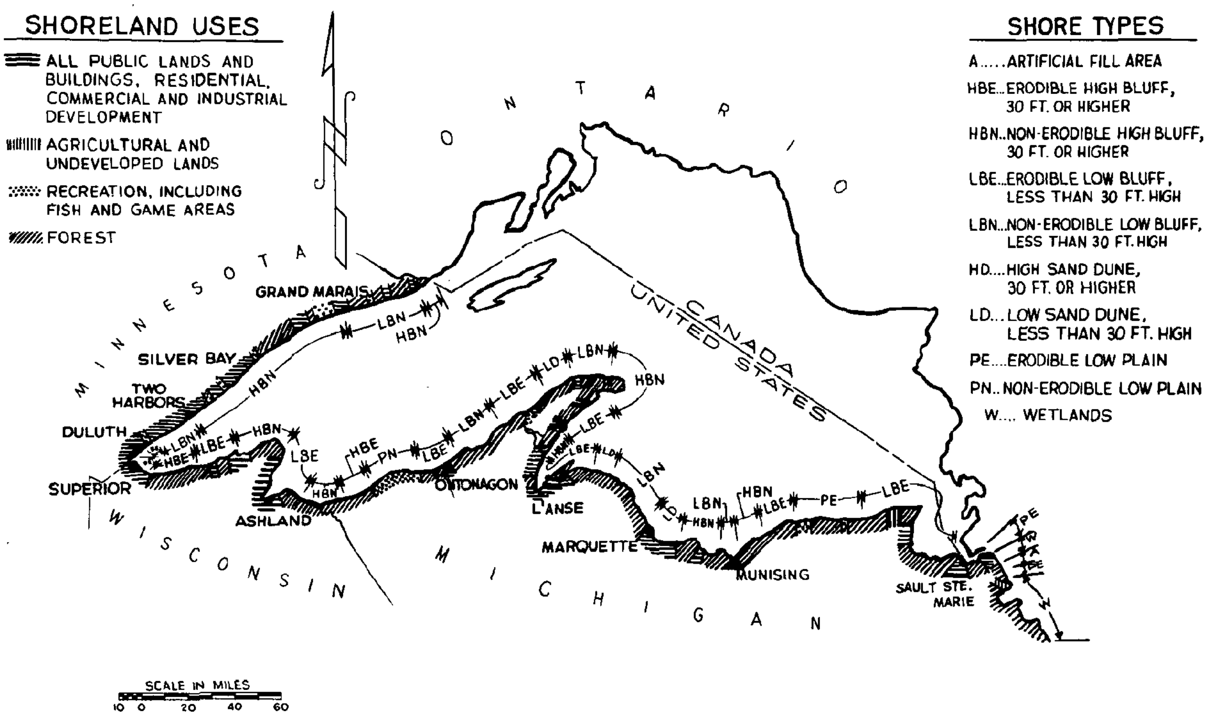

FIGURE 12–18 Shorelands of Lake Superior

5.2.1 Shoreland Description, Use, and Ownership

The shore type of Lake Superior and the St. Marys River varies from the steep rock cliffs of the Pictured Rocks National Lakeshore area, to the sandy beaches of Whitefish Bay, Michigan, to the low-lying clay and gravel bluffs near Duluth, Minnesota, and in Wisconsin, to the marshlands of Munuscong Bay, Michigan.

Table 12–10 shows the distribution of shore use, ownership, and shore form. Approximately 487 miles of Lake Superior shorelands are erodible and 86 miles of these are developed. The remaining 425 miles are nonerodible or artificially filled areas. Flooding is a problem along 11.8 miles of the shoreland.

Detailed maps showing development, ownership, physical characteristics, and environmental values along the Lake Superior and St. Marys River shorelands are included in Attachment B.

Lake Superior and the St. Marys River contain many major islands and island groups, which add greatly to the overall value of the shoreland resources of the region. The inventory data for these islands are shown in Attachment A.

5.2.2 Projected Shoreland Use and Shore Damages

A projection of changes in shoreland use and development is shown in Table 12–11. Existing and projected shoreland damages are shown in Table 12–12. Since 1952 residential use has increased slightly with a corresponding decrease in agriculture, forest, and undeveloped shorelands. The amount of land used for commercial, industrial, and public buildings has not increased since 1952. Shorelands and residentially developed lands are expected to increase from 192 miles in 1970 to 198 in 1980, 214 in 2000, and 248 in 2020. Lands used for industrial, commercial, and public buildings, 37.3 miles in 1970, are expected to increase to 47 miles in 1980, 63 in 2000, and 80 miles in 2020. Recreational use should also increase from 70.2 miles in 1970 to 84 miles in 2020. A corresponding decrease is projected in agricultural, forest, and undeveloped uses of the shorelands.

Erosion and flooding damages are related to economic and recreational uses of the erodible or flood-prone shorelands. Total potential damages for Lake Superior and the St. Marys River, estimated in Table 12–12, are based on

TABLE 12–10 Lake Superior and St. Marys River Shoreland Use, Ownership, and Shore Type

	Lake Superior			St. Marys River	
	Minnesota	Wisconsin	Michigan	Michigan	Total
Shoreland Use					
Residential	76.5	23.2	72.8	19.8	192.3
Industrial and commercial	2.7	7.7	9.2	4.5	24.1
Public lands and buildings	2.3	1.6	5.4	3.9	13.2
Agriculture and undeveloped	0.5	18.5	21.2	25.2	65.4
Recreation	24.8	3.1	42.3	0.0	70.2
Wildlife preserves	1.2	0.0	0.0	0.0	1.2
Forest lands	66.9	102.2	429.9	37.8	636.8
Shoreland Ownership					
Federal	27.5	48.2	15.7	----	(91.4)
Non-Federal public	26.0	8.5	52.5	----	(87.0)
Private	121.4	99.6	512.6	----	(733.6)
Shore Types					
Artificial fill area	0.0	6.1	0.0	3.1	9.2
Erodible high bluff	0.0	36.6	22.9	0.0	59.5
Non-erodible high bluff	99.4	20.1	105.7	0.0	225.2
Erodible low bluff	5.1	46.2	205.7	9.3	266.3
Non-erodible low bluff	64.1	4.8	101.2	4.0	174.1
High sand dune	0.0	0.0	4.0	0.0	4.0
Low sand dune	0.0	12.9	64.7	0.0	77.6
Erodible low plain	6.3	3.0	52.4	11.8	73.5
Non-erodible low plain	0.0	0.0	23.4	0.0	23.4
Wetlands	0.0	26.6	0.8	63.0	90.4
Wetlands/erodible plain	0.0	0.0	0.0	0.0	0.0
Wetlands/erodible low bluff	0.0	0.0	0.0	0.0	0.0
Total shore miles	174.9	156.3	580.8	91.2	1,003.2

TABLE 12–11 Existing and Projected Shoreland Use—Lake Superior and St. Marys River

	Miles of Shoreline			
Shoreland	1970	1980	2000	2020
Industrial, Commercial, Public Buildings, and Lands	37	47	63	79
Residential	192	196	212	245
Public Parks, Recreation	70	72	77	83
Fish and Wildlife	1	1	1	1
Agriculture, Forest, and Undeveloped	703	687	650	595
Total	1,003	1,003	1,003	1,003

TABLE 12–12 Existing and Projected Shoreland Damages—Lake Superior and St. Marys River, in thousands of dollars

	Potential Single Year Damages			
Land Use	1966	1980	2000	2020
Industrial, Commercial, Public Buildings, and Lands	5,312	6,190	7,842	10,245
Residential	3,241	4,664	8,467	15,360
Public Parks, Recreation	429	603	1,103	1,986
Agriculture, Forest, and Undeveloped	419	362	508	560
Total	9,401	11,819	17,920	28,151

the assumption that growth and development of the shorelands will follow the average growth of economic development in the area.

5.2.3 Existing and Authorized Flood and Erosion Control Projects

There are no authorized beach erosion control projects on Lake Superior. The following is a list of locations of beach erosion control studies and the authority under which they were authorized:

(1) Minnesota Point, Duluth, Minnesota, Section 111

(2) Saxon Harbor, Wisconsin, Section 111

(3) Little Girls Point, Michigan, Section 103

(4) Grand Traverse Bay, Michigan, Section 111

(5) Jacobsville, Michigan, Section 111

(6) Big Bay Harbor, Michigan, Section 111

(7) Presque Isle, Michigan, Section 111

(8) Marquette, Michigan, Section 111

(9) Grand Marais Harbor, Michigan, Section 111

(10) Whitefish Point Harbor, Michigan, Section 111

5.2.4 Possible Methods of Reducing Flood and Erosion Damages

While no single alternative will bring about a major reduction in losses due to flooding or erosion, a major reduction may be brought about in time through a combination of all available alternatives.

Shoreland management measures, including zoning, structural setbacks, acquisition, and relocation, are considered the most effective method of reducing future erosion and flooding damages on Lake Superior. This is because the density of development is low, and only 17 percent of the erodible shorelands are developed for economic uses.

The cost of structural protection required for high-value commercial and industrial sites located on shorelands is borne by the individual property owner.

Low-cost shore protection devices are needed to reduce the rate of erosion along Lake Superior's 29 miles of critical eroding shorelands developed for residential use. The cost of temporary protection is $15 million. At this time no Federal or State cost-sharing program is available to assist the shore home owner, although government subsidized insurance or physical disaster loans could be of assistance.

Existing harbors on Lake Superior can have adverse effects on coastal processes. Section 111 studies are needed for the 27 Federal harbors on Lake Superior. Ten studies are under way.

5.3 Lake Michigan

Lake Michigan (Figure 12–19) is the only Great Lake situated entirely within the United States. Its total shoreline length is 1,362 miles, parts of which are located in Wisconsin, Illinois, Indiana, and Michigan. It is distinctive from the other Great Lakes in that it is the only Great Lake which extends from north to south, which makes it the most significant transportation barrier in the Midwest. Lake Michigan contains the largest embayments of any of the Great Lakes and has the least number of islands and island groups, all of which are located in the northern one-third of the Lake. Information on the islands is shown in Attachment A. Many major urban centers including Chicago, Illinois; Milwaukee and Green Bay, Wisconsin; Hammond, Whiting, and Gary, Indiana; and Muskegon, Michigan, are situated on the shorelands. Of lesser significance are the urban centers of Manitowoc, Sheboygan, Racine, and Kenosha, Wisconsin; the Chicago suburbs of Illinois; and Benton Harbor-St. Joseph, Holland, Grand Haven, Manistee, Traverse City, Menominee, Escanaba, and Manistique, Michigan.

5.3.1 Shoreland Description, Use, and Ownership

The most impressive natural shore type of the Great Lakes is the large expanse of sand dunes along Lake Michigan's shore. These dunes extend almost continuously from the Indiana Dunes National Lakeshore northward to the tip of the Leelanau Peninsula in Michigan. They result from the prevailing westerly winds that cause an almost continuous washing and separation of shore soil materials by wave action. Often associated with the dune areas, especially during years of low water levels on the Great Lakes, are wide, sandy beaches which are heavily used for recreation.

All of the shore forms inventoried in this

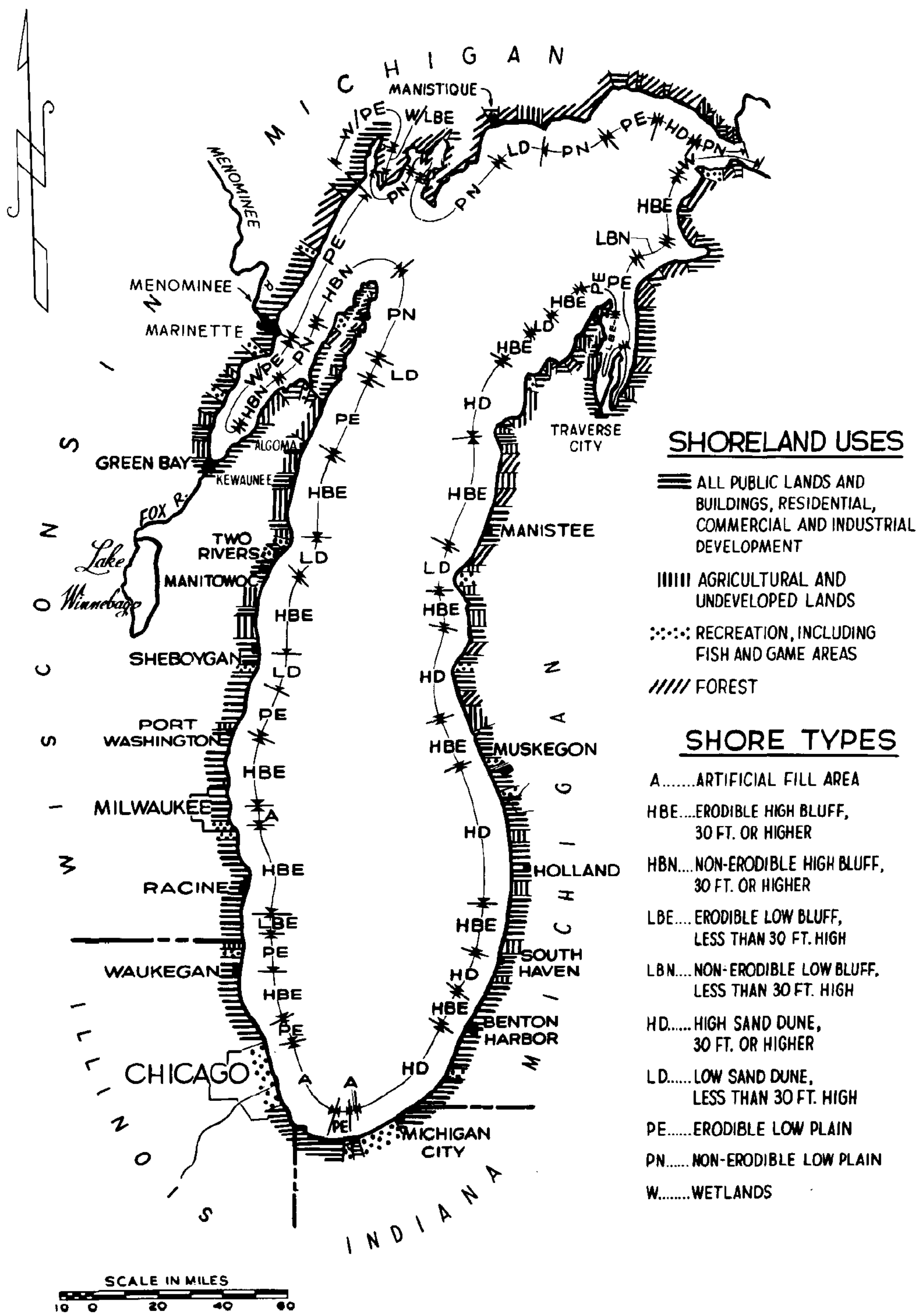

FIGURE 12–19 Shorelands of Lake Michigan

study are found on Lake Michigan. Particularly significant from the erosion standpoint are the vulnerable erodible bluff areas found along many shoreland reaches. Often used as building sites because of their scenic views, the erodible bluffs of Michigan and Wisconsin are being continuously threatened and damaged by erosion. The nonerodible bluff areas are basically limited to Michigan's Upper Peninsula portion of Lake Michigan and the northern portions of Door County, Wisconsin. Valuable marshlands providing both cover and food for fish and wildlife are extensive in Green Bay and Big and Little Bays de Noc. The wetlands of Green Bay are most often associated with low plain backlands.

With the exception of the Upper Peninsula of Michigan, some portions of northern Wisconsin, and Michigan's northern Lower Peninsula, Lake Michigan shorelands are used quite extensively for residential, commercial, industrial, and recreational developments and for agriculture. Table 12-13 illustrates the distribution of shore use, ownership, and the shore upland form. Detailed maps showing development, ownership, physical characteristics, and environmental values along the Lake Michigan shoreline are included in Attachment B.

Commercial and industrial development is concentrated in the extreme southwestern portion of the Lake, specifically western Indiana and Illinois. This use gives way to permanent and seasonal residential development north to an approximate line from Frankfort, Michigan, to Sturgeon Bay, Wisconsin. North of this line, including the Upper Peninsula of Michigan, the shorelands become less developed as agriculture and forest lands predominate.

Seasonal and permanent residential development, the greatest single shoreland use

TABLE 12-13 Lake Michigan Shoreland Use, Ownership, and Shore Type

	Wisconsin	Michigan	Illinois	Indiana	Total
Shoreland Use					
Residential	148.9	292.2	15.0	5.5	461.6
Industrial and commercial	12.9	24.7	10.5	21.8	69.9
Public lands and buildings	8.8	3.5	8.0	0.6	20.9
Agriculture and undeveloped	103.8	176.1	0.6	0.1	280.6
Recreation	54.4	58.5	30.9	17.0	160.8
Wildlife preserves	18.2	0.0	0.0	0.0	18.2
Forest lands	60.0	290.0	0.0	0.0	350.0
Shoreland Ownership					
Federal	0.0	13.0	3.1	9.3	25.4
Non-Federal public	75.2	100.2	35.8	8.7	219.9
Private	331.8	731.8	26.1	27.0	1,116.7
Shore Types					
Artificial fill area	12.4	3.8	26.6	24.6	67.4
Erodible high bluff	95.4	157.3	20.9	0.0	273.6
Non-erodible high bluff	30.1	16.8	0.0	0.0	46.9
Erodible low bluff	28.0	90.9	0.0	0.0	118.9
Non-erodible low bluff	13.1	11.6	0.0	0.0	24.7
High sand dune	0.0	128.0	0.0	11.6	139.6
Low sand dune	16.4	48.7	0.0	8.3	73.4
Erodible low plain	77.0	192.5	17.5	0.5	287.5
Non-erodible low plain	58.4	115.1	0.0	0.0	173.5
Wetlands	14.2	80.3	0.0	0.0	94.5
Wetlands/erodible plain	51.8	0.0	0.0	0.0	51.8
Wetlands/erodible low bluff	10.2	0.0	0.0	0.0	10.2
Total shore miles	407.0	845.0	65.0	45.0	1,362.0

along Lake Michigan, accounts for a total of 461.6 miles of shoreland or 33.9 percent of all shoreland use and development. The greatest percentage occurs in Michigan and Wisconsin. As a rule, residential development is more permanent in the southern portion of the Lake and becomes more seasonally scattered in the northern areas.

Although no forest lands are found along the shorelands of Indiana and Illinois, a total of 350 miles of the Lake Michigan shoreline is in forest or woodland use. The forest cover, similar to Lake Superior's, increases in the northern portion away from the populated and more developed southern shorelines of Illinois, Indiana, southern Michigan, and southern Wisconsin. The large expanses of forest add greatly to the aesthetic beauty of these northern shorelines, which are generally much less accessible than those in the southern two-thirds of the Lake.

Lake Michigan and its adjacent shorelands are used very heavily for recreation. Expanses of sandy beaches and dunes, especially on the eastern side of the Lake, are natural spots for swimming, sunbathing, picnicking, and other water-oriented recreational activities. Water temperatures, especially in the southern half of the Lake, are generally ideal for swimming from late June through early September. Water quality is generally good except in isolated areas associated with industrial activity in the extreme southern portion of the Lake and in parts in Green Bay. The Lake has become very popular for sport fishing since the recent introduction of coho, chinook, and Atlantic salmon. Excellent panfish fishing, particularly for yellow perch, exists near the numerous harbors and piers along Lake Michigan shores. During winter months, the dunes and beaches in many State parks and other public recreational areas are used for skiing and snowmobiling.

Of the 245 miles of publicly owned Lake Michigan shorelands, 156 miles are Federal, State, and local parks and recreation areas. Of particular interest is the entire shoreline of the city of Chicago which is beautifully developed and open to public recreation. Significant recreation areas along the shoreline of Lake Michigan include Indiana Dunes State Park and National Lakeshore, Indiana; the Sleeping Bear Dunes National Lakeshore, Michigan; Wisconsin State Parks; Michigan State Parks; Hiawatha and Manistee National Forest; and the Chicago waterfront. Much of the private shorelands of Lake Michigan are also extensively used for recreation as is evidenced by the large number of cottages that dot the shoreline. In addition, the marshlands of Green Bay provide excellent waterfowl hunting in the fall.

5.3.2 Projected Shoreland Use and Shore Damages

Projected change in shoreland use and development is shown in Table 12–14. Existing and projected shoreland damages are shown in Table 12–15. Since 1952, residential use has increased significantly with a corresponding decrease in agriculture, forest, and undeveloped shorelands. Residential shorelands are expected to increase from 462 miles in 1970 to 494 miles in 1980, to 540 miles in 2000, and to 677 miles in 2020. Lands related to industrial, commercial, and public buildings are expected to increase from 91 miles in 1970 to 97 miles in 1980, 106 miles in 2000, and 113 miles in 2020. Recreational use should increase from 161 miles in 1970 to 195 miles in 2020. A corresponding decrease is projected in agricultural, forest, and undeveloped use of the shorelands.

TABLE 12–14 Existing and Projected Shoreland Use—Lake Michigan

	Miles of Shoreline			
Shoreland Use	1970	1980	2000	2020
Industrial, Commercial, Public Buildings, and Lands	91	97	106	113
Residential	462	994	540	577
Public Parks, Recreation	161	172	188	195
Fish and Wildlife	18	18	18	18
Agriculture, Forest, and Undeveloped	630	581	510	459
Total	1,362	1,362	1,362	1,362

Approximately 1050 miles of Lake Michigan shorelands are erodible, of which 448 miles are economically developed. The remaining 313 miles of shoreland are nonerodible or artificial fill areas.

Erosion and flooding damages are related to economic and recreational uses of the erodible or flood-prone shorelands. Total potential damages for Lake Michigan, estimated in Table 12–15, are based on the assumption that growth and development of the shorelands will follow the average growth of economic development in the area.

TABLE 12-15 Existing and Projected Shoreland Damages—Lake Michigan, in thousands of dollars

Land Use	Potential Single Year Damages 1966	1980	2000	2020
Industrial, Commercial, Public Buildings, and Lands	1,685	2,110	2,769	2,855
Residential	21,536	32,841	56,282	56,216
Public Parks, Recreation	4,427	7,754	16,657	27,168
Agriculture, Forest, and Undeveloped	2,250	2,219	2,512	3,104
Total	29,898	44,924	78,220	89,343

5.3.3 Existing and Authorized Flood and Erosion Control Projects

There are seven authorized beach erosion control projects on Lake Michigan. The following is a list of locations of authorized beach erosion control studies and the authority under which they were authorized:

(1) Milwaukee County Shoreline, Wisconsin, Resolution
(2) Illinois Shore of Lake Michigan, Illinois, Resolution
(3) Indiana Shoreline Erosion, Indiana, Resolution
(4) Michigan City Harbor, Indiana, Section 111
(5) St. Joseph Harbor, Michigan, Section 111
(6) Hagar Township, Michigan, Section 103
(7) South Haven Harbor, Michigan, Section 111
(8) Holland Harbor, Michigan, Section 111
(9) Grand Haven Harbor, Michigan, Section 111
(10) Muskegon Harbor, Michigan, Section 111
(11) White Lake Harbor, Michigan, Section 111
(12) Pentwater Harbor, Michigan, Section 111
(13) Ludington Harbor, Michigan, Section 111
(14) Manistee Harbor, Michigan, Section 111
(15) Portage Lake Harbor, Michigan, Section 111
(16) Frankfort Harbor, Michigan, Section 111
(17) Empire, Michigan, Section 103
(18) Leland Harbor, Michigan, Section 111

5.3.4 Possible Methods of Reducing Flood and Erosion Damages

No single alternative will bring about a major reduction in losses from erosion and flooding. However, extensive residential, commercial, and industrial development in Planning Subareas 2.2 and 2.3 suggests that structural protection would be the most effective method of damage reduction. Permanent structural protection is provided by commercial and industrial developments located on the Lake as part of site development plans. Low-cost shore protection is required for residential development along Lake Michigan's 130 miles of critically eroding shoreland. The cost of providing temporary protection for residential development is $65 million.

Shoreland management measures, including zoning, structural setbacks, acquisition, and relocation, are considered the most effective methods of reducing future erosion damages on Lake Michigan, particularly in Planning Subareas 2.1 and 2.4. Low density of development and undeveloped shorelands suggest that zoning relocation and structural setbacks would be the best measures.

5.4 Lake Huron

Lake Huron, (Figure 12-20) the second largest of the Great Lakes, is separated from Lake Michigan by the Straits of Mackinac. Lake Huron's United States shoreland, a total mainland length of 565 miles, is entirely within the State of Michigan, but the majority of the total shoreline, including Georgian Bay, is under the jurisdiction of the Canadian Province of Ontario.

Other than Lake Superior, Lake Huron is the least developed of the Great Lakes. The water quality of the Lake is good except for an isolated problem in Saginaw Bay. The prevailing westerly winds affect the recreational value of the Lake in that warm surface waters are blown eastward, which allows cool waters to surface along the western shore. This limits swimming and other body contact water-oriented activities.

The Lake contains significant fishery and wildlife value, especially in the marshy Saginaw Bay area and the Les Cheneaux Island group. Saginaw Bay is the most significant fish and wildlife habitat area on the Great Lakes.

The few municipalities of any size located on the United States shorelands of Lake Huron

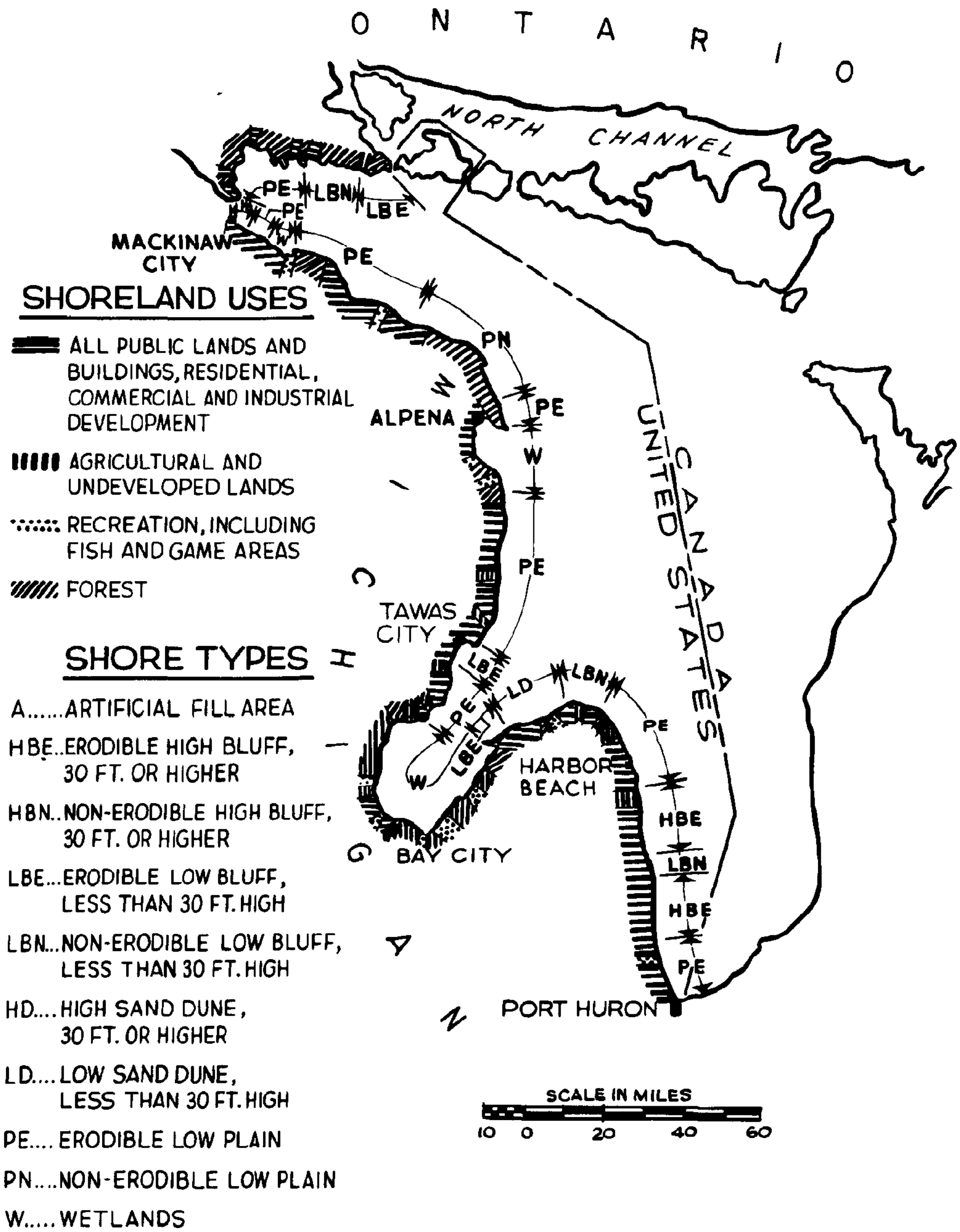

FIGURE 12–20 Shorelands of Lake Huron

are Cheboygan, Alpena, East Tawas-Tawas City, Bay City, and Port Huron. Consequently, very little commercial and industrial activity is currently in evidence along the shorelands except at Bay City, Rogers City, Alpena, and Cheboygan.

Lake Huron contains more islands than any of the other Great Lakes and many contribute a great deal to the overall value, use, and development of the Lake. The island resources of Lake Huron are described in Attachment A.

5.4.1 Shoreland Description, Use, and Ownership

Lake Huron's shore type is quite different from that of Lake Michigan and Lake Superior. It is mainly a rock and boulder shore in the northern area with some high bank beaches extending landward into a rolling upland area. Saginaw Bay is characterized by wetlands. From Sand Point in outer Saginaw Bay to the most northern part of Huron County, the shore is sandy beaches backed by low dunes and bluffs. This shore type also predominates in Sanilac County. From northern Huron County east and south approximately to the Huron-Sanilac County line exposed bedrock and very rocky shorelands replace the sandy shore type with a picturesque shoreline.

Lake Huron's U.S. shorelands are used and developed lightly from Mackinaw City southward to the most populated areas near Tawas City and Bay City. Seasonal and permanent housing predominates except in larger municipal areas where some commercial and industrial development interrupts. Farmland immediately behind residential development on the shoreline is common in many areas. Forest lands are prevalent in the northern portion of the Lake basin as well, but many of these undeveloped agricultural and forested areas are slowly being converted to residential use. Although overland transportation routes provide access to the Huron shoreline north of Bay City, freeways and other high speed roadways are noticeably absent, which may explain the relatively light development of this shoreland area. Only 12 percent of the total holdings bordering northern Lake Huron are publicly owned.

The southern portion of Lake Huron from Saginaw Bay southward to Port Huron, Michigan, is developed to a greater degree than the north, but is similar to the north in that residential and agricultural development again predominates in most rural areas, especially in Huron and Sanilac Counties, Michigan. Commercial and industrial development which accounts for only 2 percent of the total shoreland use in this southern Lake Huron area, is concentrated mainly in the Bay City area. Because of the marshy shore type of the Saginaw Bay area, large tracts of shorelands in Tuscola and Huron Counties are almost completely undeveloped except for agricultural use inland from the marshlands.

Table 12-16 shows the distribution of shore use, ownership, and shore type. Detailed maps showing the development, physical characteristics, and environmental values along the Lake Huron shorelands are given in Attachment B.

Of Lake Huron's approximately 460 miles of erodible shorelands, 218 miles are developed. The remaining 105 miles are nonerodible or artificial fill areas. Flooding is a problem along 75 miles of the shoreland.

TABLE 12-16 Lake Huron Shoreland Use, Ownership, and Shore Type

	Michigan
Shoreland Use	
Residential	236.9
Industrial and commercial	17.3
Public lands and buildings	2.4
Agriculture and undeveloped	84.7
Recreation	25.6
Wildlife preserves	17.1
Forest lands	181.0
Shoreland Ownership	
Federal	9.5
Non-Federal public	56.4
Private	499.1
Shore Types	
Artificial fill area	0.0
Erodible high bluff	34.7
Non-erodible high bluff	0.0
Erodible low bluff	59.7
Non-erodible low bluff	60.0
High sand dune	0.0
Low sand dune	18.4
Erodible low plain	183.6
Non-erodible low plain	45.4
Wetlands	163.2
Wetlands/erodible plain	
Wetlands/erodible low bluff	
Total shore miles	565.0

5.4.2 Projected Shoreland Use and Shore Damages

Projected changes in shoreland use and development are shown in Table 12–17. Since 1952 residential use has increased slightly with a corresponding decrease in agriculture, forest, and undeveloped shorelands. Commercial, industrial, and public buildings and related lands have not increased since 1952. Residential use of the shorelands totaled 237 miles in 1970, and is expected to increase to 248 in 1980, 267 in 2000, and 286 in 2020. Lands related to industrial, commercial, and public buildings are expected to increase from 20.0 miles in 1970 to 23 miles in 2020. A corresponding decrease is projected in agricultural, forest, and undeveloped uses of the shorelands.

Total erosion and flood damages which are related to economic and recreational uses of the erodible or flood-prone shorelands, are estimated for Lake Huron in Table 12–18. These projections are based on the assumption that growth and development of the shorelands will follow the average growth of economic development in the area.

TABLE 12–17 Existing and Projected Shoreland Use—Lake Huron

	Miles of Shoreline			
Shoreland Use	1970	1980	2000	2020
Industrial, Commercial, Public Buildings, and Lands	20	21	22	23
Residential	237	248	267	286
Public Parks, Recreation	26	26	26	26
Fish and Wildlife	17	17	17	17
Agriculture, Forest, and Undeveloped	265	253	233	213
Total	565	565	565	565

TABLE 12–18 Existing and Projected Shoreland Damages—Lake Huron, in thousands of dollars

	Potential Single Year Damages			
Land Use	1966	1980	2000	2020
Industrial, Commercial, Public Building, and Lands	16	21	28	27
Residential	1,437	2,449	5,139	10,616
Public Parks, Recreation	27	48	106	241
Agriculture, Forest, and Undeveloped	13	15	19	21
Total	1,493	2,533	5,292	10,905

5.4.3 Existing and Authorized Flood and Erosion Control Projects

There are no authorized beach erosion control projects on Lake Huron. The following is a list of locations of authorized beach erosion control studies and the authority under which they were authorized:

(1) Hammond Bay Harbor, Michigan, Section 111

(2) Harrisville Harbor, Michigan, Section 111

(3) Harbor Beach Harbor, Michigan, Section 111

(4) Port Sanilac Harbor, Michigan, Section 111

(5) Shore of Lake Huron, Lexington Heights, Michigan, Resolution

5.4.4 Possible Methods of Reducing Flood and Erosion Damages

Shoreland management measures including zoning, structural setbacks, acquisition, and relocation are considered the most effective methods of reducing future erosion and flooding damages. Because sixty percent of the erodible shorelands of Lake Huron are undeveloped, proper land use regulations can reduce future erosion damages.

Flooding is a problem on 75 miles of shoreland located along Saginaw Bay, which is currently undeveloped. Pressure for use of these flood plain areas will be extremely intense in the next few years. Flood plain studies are needed to delineate flood-prone areas.

Structural erosion control measures are needed for the eight miles of critically eroding shorelands. The cost of this protection is approximately $4 million.

5.5 Lake Erie, St. Clair River, Lake St. Clair, the Detroit River, and the Niagara River

Lake Erie (Figure 12–21) surpasses only Lake Ontario in size. Its United States and Canadian shores are only 58 miles apart at the widest point, and it has the shallowest maximum depth of all the Great Lakes, only 210 feet. The 30-foot depth contour is approximately one mile offshore all around the shoreline, which contributes to the great fluctuations in water level. These fluctuations are greater than those on any of the other Great Lakes. Strong winds blowing along the axis of

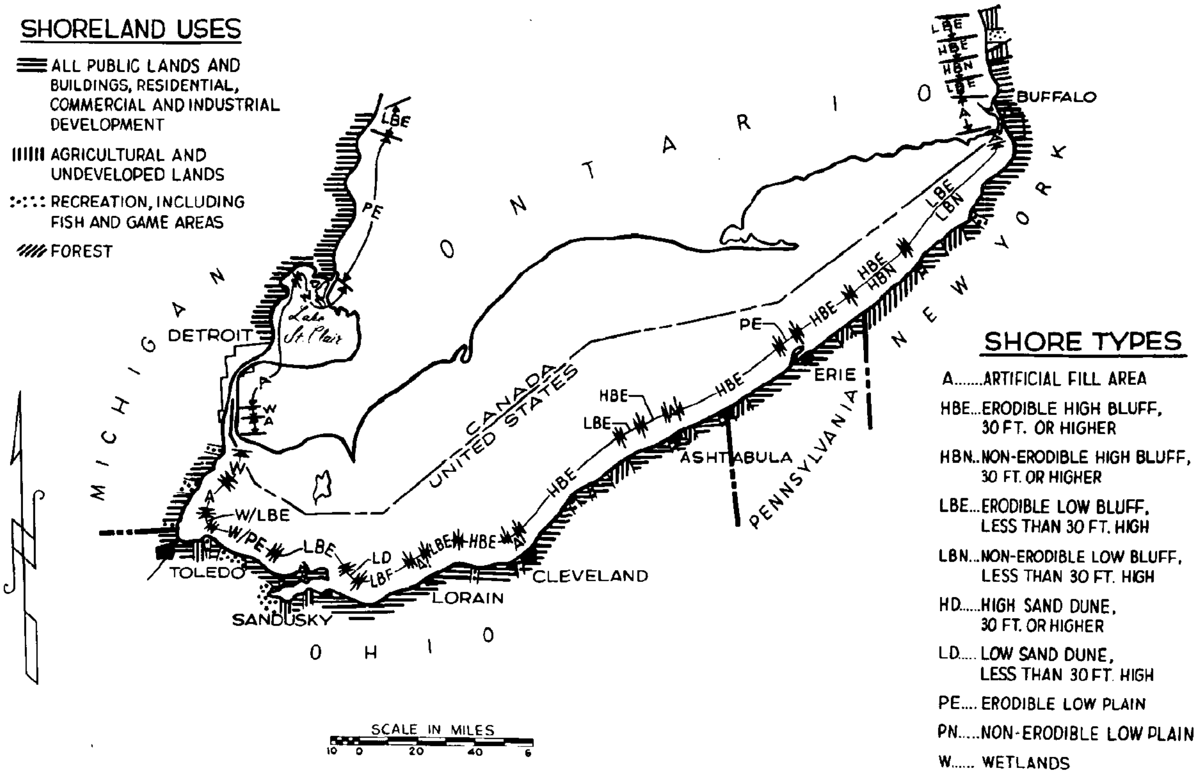

FIGURE 12–21 Shorelands of Lake Erie

the Lake can create seiches that have been known to lower the water level at one end of the Lake by eight feet or more, while the water depth of harbors at the other end of the Lake rises several feet.

Michigan, Ohio, Pennsylvania, and New York have jurisdiction over the 342 miles of Lake Erie shorelands in the United States.

The United States shorelands of the St. Clair River, Lake St. Clair, and the Detroit River are all under the jurisdiction of the State of Michigan. Abutting the most populated area of Michigan, they are the most heavily developed of all shorelands in the State. The 115-mile long waterway, which divides the so-called upper Great Lakes (Superior, Michigan, and Huron) from the lower Great Lakes (Erie and Ontario), is heavily used for navigation.

The United States shorelands of the Niagara River are under the jurisdiction of the State of New York. The Niagara River flows from Lake Erie generally north, for 33 miles on the shortest channel to Lake Ontario. The river falls approximately 326 feet at Niagara Falls, which is 19 miles below Lake Erie. There are several power plants, both in the United States and Canada that make use of the available energy to produce hydro-electric power. The Maid-of-the-Mist Pool and the Falls create a popular tourist attraction.

The City of Detroit is the major metropolitan area on the shorelands of southern Lake St. Clair and the Detroit River, but many suburban communities of significance also occupy the shoreline areas. The use and development of the shorelands of the St. Clair River, Lake St. Clair, and the Detroit River are urban oriented, with residential, commercial, and industrial development predominating.

Significant urban areas, in addition to Detroit and its suburbs, are Port Huron, St. Clair, Marine City, Algonac, New Baltimore, and Mt. Clemens, all located on the St. Clair River and the northern portion of Lake St. Clair.

The Lake Erie and the Niagara River shorelands are highly developed with major urban areas such as Monroe, Michigan; Toledo, Sandusky, Lorain, Cleveland, and Ashtabula, Ohio; Erie, Pennsylvania; and Buffalo, New York.

5.5.1 Shoreland Description, Use, and Ownership

Permanent residential homes account for a total of 67.1 miles or 58.3 percent of the total development along the shores of Lake St. Clair, St. Clair River, and Detroit River (Table 12–19). The next most important shoreland developments within southeastern Michigan are industrial and commercial. Heavy industry, in the form of large steel and auto companies and related industry is especially prevalent along the lower Detroit River. Commercial developments are concentrated along Detroit's waterfront.

Agriculture and undeveloped lands along the St. Clair River, Lake St. Clair, and the Detroit River account for only 9.3 miles or 8.1 percent of the total shoreline use and development. Most of the undeveloped or agricultural lands are located in the northernmost portion of this shoreland area, but there are no forest lands found in this area.

The State of Michigan has 32.5 miles, or 9.5 percent of the shorelands of Lake Erie, almost all of which are located in Monroe County. The shore types of this stretch of shoreline vary but basically consist of wetlands interspersed with artificial shore types in and near the more developed areas.

Residential development accounts for 15 miles or almost 50 percent of the total shoreland use of the Michigan portion of Lake Erie. As opposed to many other Great Lake shoreland areas in Michigan, residential development on Lake Erie is permanent, undoubtedly due to the proximity of Detroit and Toledo. The residential use of the shore is widespread and not confined to the shorelands immediately adjacent to the City of Monroe.

Almost 11 miles, or 33.8 percent, of Michi-

TABLE 12–19 St. Clair River, Lake St. Clair, and Detroit River Shoreland Use, Ownership, and Shore Type

	St. Clair River	Lake St. Clair	Detroit River	Total
Shoreland Use				
Residential	25.9	36.1	5.1	67.1
Industrial and commercial	8.7	1.9	19.0	29.6
Public lands and buildings	0.0	2.3	0.0	2.3
Agriculture and undeveloped	1.7	2.5	5.1	9.3
Recreation	0.7	2.1	1.8	4.6
Wildlife preserves	0.0	2.1	0.0	2.1
Forest lands	0.0	0.0	0.0	0.0
Shoreland Ownership				
Federal	0.0	0.0	0.0	0.0
Non-Federal public	0.7	6.5	1.8	9.0
Private	36.3	40.5	29.2	106.0
Shore Types				
Artificial fill area	0.0	31.1	25.4	56.5
Erodible high bluff	0.0	0.0	0.0	0.0
Non-erodible high bluff	0.0	0.0	0.0	0.0
Erodible low bluff	5.6	0.0	0.0	5.6
Non-erodible low bluff	0.0	0.0	0.0	0.0
High sand dune	0.0	0.0	0.0	0.0
Low sand dune	0.0	0.0	0.0	0.0
Erodible low plain	31.4	3.4	0.0	34.8
Non-erodible low plain	0.0	0.0	0.0	0.0
Wetlands	0.0	12.5	5.6	18.1
Total shore miles	37.0	47.0	31.0	115.0

gan's Lake Erie shorelands are State-owned designated recreational and wildlife areas.

The Michigan portion of the shoreline of Lake Erie is devoid of forest land except for isolated woodlots. Agriculture and undeveloped use, however, accounts for 5.8 miles or 17.8 percent. As with other Great Lake shoreland areas, these undeveloped lands are slowly giving way to residential use.

The State of Ohio includes 190.3 miles, or 55.6 percent of the United States shorelands of Lake Erie. These are intensely developed lands as indicated in Figure 12-21. Only 14 percent of the Ohio shorelands are undeveloped or used agriculturally. An additional two percent covered with forest is scattered all along the Ohio shoreline.

Residential development, generally permanent and uniformly distributed along the entire Ohio shoreline, accounts for 51 percent of the existing shore property use.

Recreational parks and wildlife preserves account for 19 percent of the Ohio shorelands. More than 10 miles of wetlands at the west end of Lake Erie in the vicinity of Reno Beach are State and Federally owned and developed as wildlife preserves.

Industrial developments which make up only 8 percent of the Ohio shore property uses, are concentrated primarily in the eastern portion of the State in the Cities of Conneaut, Ashtabula, Painesville, Fairport Harbor, Cleveland, and Lorain. Industries are concentrated in Toledo at the extreme western end of the State.

Approximately one-fourth of the Ohio shorelands, including wildlife refuges and parks, are publicly owned.

There is a serious lack of parks and other recreational facilities along the shorelands of this waterway, although the waterway itself is heavily used for recreational boating. Many marinas along the shoreline berth thousands of recreational watercraft, many of which boat on Lake St. Clair on summer weekend afternoons.

Table 12-19 describes the distribution, ownership, and shore type for the St. Clair River, Lake St. Clair, and the Detroit River. Detailed maps showing use, ownership, physical characteristics, and environmental values along these shorelands are given in Attachment B.

Table 12-20 summarizes the distribution shoreland use, ownership, and shore types along Lake Erie and the Niagara River. Detailed maps of use, ownership, physical characteristics, and environmental values along the Lake Erie and Niagara River shorelands are provided in Attachment B. Of the approximately 290 miles of erodible Lake Erie shorelands, 162 miles are developed. The remaining 52 miles are nonerodible or artificially filled areas. Flooding is a problem along 44 miles of the shoreland.

Shore types along Ohio shoreline range from the wetlands, low erodible bluffs, and erodible plain shore in the western one-third of the State to the high erodible glacial till and soft shale bluffs located in the eastern two-thirds of the State.

Erie County, Pennsylvania, has a shore frontage of 48.3 miles, the only Pennsylvania frontage on Lake Erie and the Great Lakes. Its shore bluffs are generally 50 to 75 feet high and rise to 100 feet in a few places. The western one-half of the shore between the Ohio-Pennsylvania line and Erie has bluffs entirely of silt, clay, and granular material, with shale bedrock at about water level. To the east of Erie Harbor, the shale bedrock is frequently from 15 to 35 feet above the lake level, and the upper part of the bluff is composed of silt, clay, and granular material. Sand and gravel beaches up to 150 feet wide extend along the toe of the bluffs.

The eight miles of shore from the Ohio-Pennsylvania line to the mouth of Elk Creek is sparsely populated. Between Elk Creek and the New York State line the shoreland development increases with many expensive permanent homes.

The Lake Erie shores of New York's Chautauqua and Erie Counties measure 70.9 miles and are characterized by high erodible bluffs. The average height of the shore bluffs is 40 to 50 feet, but it extends to 100 feet in short reaches. The lower part of the bluffs, generally well above the limit of wave uprush, is shale. In some places, shale extends the full height of the bluff, but more often the top half is unconsolidated. For some distance on either side of river mouths the bluffs are lower.

The Lake Erie shoreline of Erie County between Cattaraugus Creek and Lackawanna, a distance of approximately 22 miles, is a highly developed residential area. There are occasional open spaces, including Evangola State Park and approximately seven smaller public recreation areas. The shoreline of Lackawanna and Buffalo to the mouth of the Buffalo River is much wider and deeper than along upper sections of the river and remains relatively calm. The main channel, which is 30 feet deep where it enters the Lake, is rather narrow and crooked and meanders through

TABLE 12–20 Lake Erie and Niagara River Shoreland Use, Ownership, and Shore Type

	Lake Erie				Niagara River	
	New York	Pennsylvania	Ohio	Michigan	New York	Total
Shoreland Use						
Residential	24.7	21.2	96.4	15.0	4.2	161.5
Industrial and commercial	9.0	3.6	15.0	0.8	6.6	35.0
Public lands and building	4.9	0.0	11.9	0.0	7.9	24.7
Agriculture and undeveloped	24.4	11.9	26.1	5.8	11.7	79.9
Recreation	7.9	11.6	25.7	2.8	8.6	56.6
Wildlife preserves	0.0	0.0	10.8	8.1	0.0	18.9
Forest lands	0.0	0.0	4.4	0.0	0.0	4.4
Shoreland Ownership						
Federal	0.0	0.0	6.8	0.0	----	(6.8)
Non-Federal public	12.8	11.6	35.7	10.9	----	(71.0)
Private	58.1	36.7	147.8	21.6	----	(264.2)
Shore Types						
Artificial fill area	9.1	0.0	15.1	18.2	11.3	53.7
Erodible high bluff	33.1	40.6	72.7	0.0	6.2	152.6
Non-erodible high bluff	0.0	0.0	2.0	0.0	6.7	8.7
Erodible low bluff	25.9	0.0	55.1	0.0	11.3	92.3
Non-erodible low bluff	0.6	0.0	5.5	0.0	0.4	6.5
High sand dune	0.0	0.0	0.0	0.0	0.0	0.0
Low sand dune	0.0	0.0	12.4	0.0	0.0	12.4
Erodible low plain	0.9	7.7	19.9	0.0	3.1	31.6
Non-erodible low plain	1.3	0.0	0.0	0.0	0.0	1.3
Wetlands	0.0	0.0	4.1	14.3	0.0	18.4
Wetlands/erodible plain	0.0	0.0	3.5	0.0	0.0	3.5
Wetlands/erodible low bluff	0.0	0.0	0.0	0.0	0.0	0.0
Total shore miles	70.9	48.3	190.3	32.5	39.0	381.0

sand bars where the depth is only 10 to 15 feet.

Shore use along the American side of the Niagara River is diversified. From the headwaters, proceeding north through Buffalo, Tonawanda, North Tonawanda, and Niagara Falls, there is intensive industrial development, including automobile manufacturing, a paper mill, oil refineries, lumber mills, power plants, and numerous other smaller industries. Public parks, small-boat harbors, and scenic points of interest are located along parkways that border several miles of the river. A State park at Niagara Falls provides public access to this scenic wonder that attracts from 5 to 10 million visitors per year.

Below the Falls, proceeding north for approximately 10 miles, Niagara Gorge provides a scenic experience second only to the Falls itself. Parkways, public parks, and residential land use are typical in this area.

5.5.2 Projected Shoreland Use and Shore Damages

Projected changes in shoreland use and development, shown in Table 12–21, indicate that the entire shoreland will be developed by the year 2000. Residential use of the shorelands, which covered 161 miles in 1970 is expected to increase to 190 miles in 1980, 227 miles in 2000, and 223 miles in 2020. Lands related to industrial, commercial, and public buildings are expected to increase from 60 miles in 1970 to 78 miles in 2020. Recreational use should also increase from 57 miles in 1970 to 61 miles in 2020.

TABLE 12–21 Existing and Projected Shoreland Use—Lake Erie

	Miles of Shoreline			
Shoreland Use	1970	1980	2000	2020
Industrial, Commercial, Public Buildings, and Lands	60	69	74	78
Residential	161	190	227	223
Public Parks, Recreation	57	58	61	61
Fish and Wildlife	19	19	19	19
Agriculture, Forest, and Undeveloped	84	45	0	0
Total	381	381	381	381

Total potential erosion and flooding damages, which are related to economic and recreational uses of the erodible or flood-prone shorelands, are estimated for Lake Erie in Table 12–22. These projections are based on the assumption that growth and development of the shorelands will follow the average growth of economic development in the area.

TABLE 12–22 Existing and Projected Shoreland Damages—Lake Erie, in thousands of dollars

Land Use	Potential Single Year Damages 1966	1980	2000	2020
Industrial, Commercial, Public Buildings, and Lands	450	437	-----	------
Residential	3,800	6,503	14,714	25,283
Public Parks, Recreation	1,769	1,814	270	556
Agriculture, Forest, and Undeveloped	896	778	382	272
Total	6,915	9,097	15,366	26,111

5.5.3 Existing and Authorized Flood and Erosion Control Projects

There are 15 completed beach erosion control reports on Lake Erie. The following is a list of the locations of authorized beach erosion control studies and the authority under which they were authorized:

(1) Monroe Harbor, Michigan, Section 111
(2) Bolles Harbor, Michigan, Section 111
(3) Ashtabula-Lake County Line to Ashtabula, Ohio, Resolution
(4) Conneaut Harbor, Ohio, Section 111
(5) Presque Isle, Erie, Pennsylvania, Resolution

5.5.4 Possible Methods of Reducing Flood and Erosion Damages

Lake Erie basin shore damage problems are complex. Most of the shorelands, 290 miles, are erodible and 162 miles of these are developed. Flooding is a problem on 44 miles of shorelands. Projections of future shoreland use show all of Lake Erie's shorelands committed to urban uses by 2000. The percentage of developed shoreline and density of development suggest that structural shore protection would be the most effective method of reducing damages to existing development. Additional regulation of Lake Erie is also a possibility. Approximately 25.2 miles of erodible shorelands are critical where structural protection appears to be economically justified. The first cost of this protection is estimated at 12.6 million. The cost of this protection would have to be borne entirely by the shore home owner, but government subsidized insurance or physical disaster loans could reduce his burden.

Existing harbors on Lake Erie can have adverse effects on coastal processes. Section 111 studies, three of which are under way, are needed for the 11 Federal harbors on Lake Erie.

Future activities on undeveloped shorelands should be controlled to reduce future damages. Shoreland management measures including setbacks in zoning, acquisition, and relocation could reduce future damages on Lake Erie.

5.6 Lake Ontario

Lake Ontario, the smallest of the Great Lakes, has the shortest shoreline within the United States. Lying entirely within the State of New York, it extends 289.6 miles from the mouth of the Niagara River to Tibbett's Point at the head of the St. Lawrence River.

New York's Lake Ontario shoreline is fairly regular, running in an east-west direction from the mouth of the Niagara River for approximately 160 miles, as shown on Figure 12–22. The shoreline then diverts to a north-south direction, becoming irregular with several large bays in the northern half. Rochester is the major urban center located on Lake Ontario.

5.6.1 Shoreland Description, Use, and Ownership

The distribution of shore types along the Ontario shoreline is shown in Table 12–23. The east-west portion of the shoreline consists generally of bluffs of glacial material ranging from 20 to 60 feet high. Narrow gravel beaches border the bluffs, which are subject to erosion by wave action. The bluffs are broken in several places by low marshes. The shore in the vicinity of Rochester and Irondequoit is marshy with sand and gravel barrier beaches separating the marshes and open ponds from the Lake. The shoreline from Sodus Bay east to Port Ontario is a series of drumlins and dunes separated by marsh areas. North of the

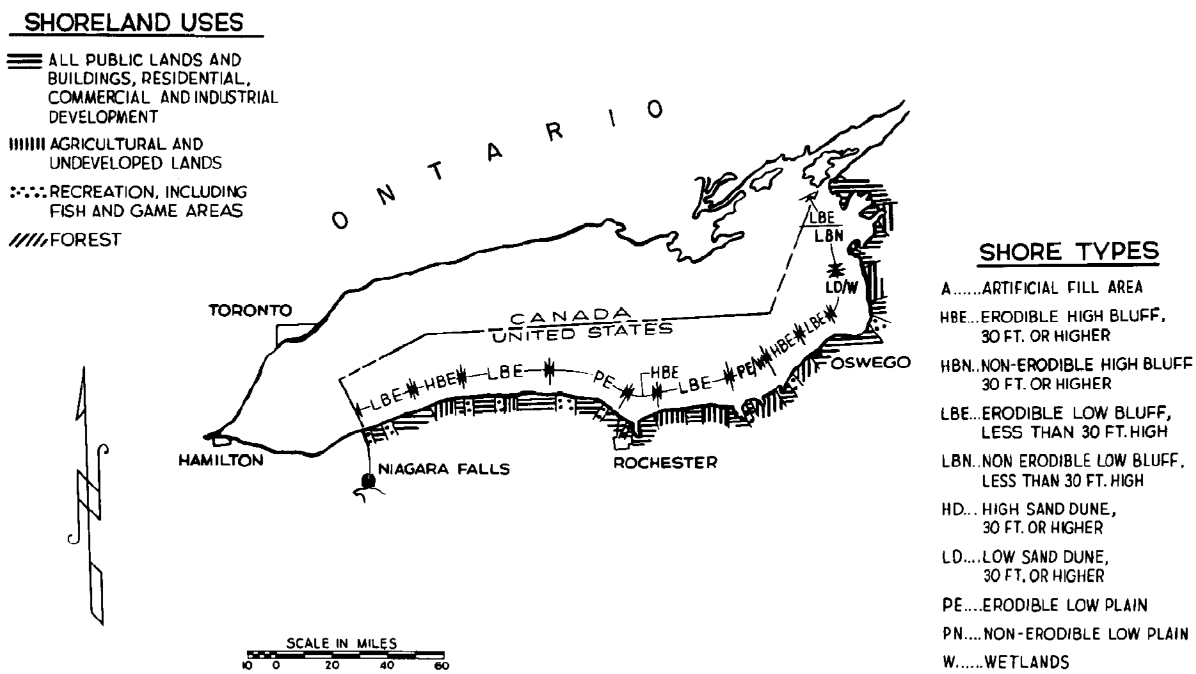

FIGURE 12–22 Shorelands of Lake Ontario

TABLE 12–23 Lake Ontario Shoreland Use, Ownership, and Shore Type

	New York
Shoreland Use	
Residential	127.0
Industrial and commercial	20.8
Public lands and buildings	1.7
Agriculture and undeveloped	109.9
Recreation	30.2
Wildlife preserves	0.0
Forest lands	0.0
Shoreland Ownership	
Federal	0.0
Non-Federal public	31.9
Private	257.7
Shore Types	
Artificial fill area	3.1
Erodible high bluff	33.6
Non-erodible high bluff	8.3
Erodible low bluff	91.2
Non-erodible low bluff	106.1
High sand dune	0.0
Low sand dune	0.0
Erodible low plain	12.0
Non-erodible low plain	0.0
Wetlands	35.3
Total shore miles	289.6

Oswego-Jefferson County line for a distance of 10 miles, the shorelands are composed of dunes and barrier beaches. At this point the shore type changes abruptly to rock outcrop at the water's edge. This rock shore extends north to the St. Lawrence River, interrupted only by a few pockets of beaches and marshes at the inner ends of the deep bays. Detailed maps showing development, ownership, physical characteristics, and environmental values along the Ontario shorelands are provided in Attachment B.

Residential development comprises 127.0 miles, or 44 percent of the shoreline, while agricultural and undeveloped lands amount to 109.9 miles, or 38 percent. The remaining 52.7 miles are divided between recreational uses (10 percent), industrial and commercial (7 percent), and public buildings and related lands (1 percent). There are 39.1 miles of publicly owned shoreland.

The larger commercial and industrial developments are centered at Rochester and Irondequoit, but there also are industrial developments at Sodus Point, and commercial developments at Henderson Harbor and Sachet Harbor. Several parks and recreation areas, including 14 State parks, are scattered along the New York shorelands. There are also numerous county and local parks and recreation areas located along the shore. Except for the Cities of Rochester, Irondequoit, and Oswego, the developed areas consist of a few small communities and scattered strips of residential development adjacent to the shore. Behind the residential strip, the land is generally undeveloped or used for agriculture. Fruit crops predominate in the agricultural lands between Irondequoit and Oswego.

Serving the recreational boating demand are approximately 24 harbors or marinas spaced fairly evenly along the shoreline, and several launching ramps located on rivers leading to the Lake. Many of the marinas are located at State and local parks. Rochester, Oswego, and Great Sodus have Federally maintained deep-draft harbors for commercial navigation.

5.6.2 Projected Shoreland Use and Shore Damages

Projected change in shoreland use and development is shown in Table 12-24. Residential use of the shorelands is expected to increase from 127 miles in 1970 to 134 miles in 1980, 194 miles in 2000, and 207 miles in 2020. Land related to industrial, commercial, and public buildings should show a slight increase from 23 miles in 1970 to 28 miles in 2020. Recreation use of the shorelands will also increase. A corresponding decrease is expected in agricultural, forest, and undeveloped use of the shorelands.

Erosion and flooding damages are related to economic or recreational use of erodible or flood-prone shorelands. Of Lake Ontario's 170 miles of erodible shoreland, 84 miles are economically developed. The remaining 86 miles of shorelands are classified as nonerodible or artificial fill areas. Flooding is a problem along 47 miles of shorelands. Projected total potential damages for Lake Ontario, estimated in Table 12-25, are based on the assumption that growth and development of the shorelands will follow the average growth of economic development in the area.

Shoreland management measures, including zoning, structural setbacks, acquisition, and relocation, are considered the most cost effective methods of reducing future erosion and flooding damages on Lake Ontario because 50 percent of the erodible shoreland is already developed.

The cost of structural protection required for high-value commercial and industrial sites in shoreland locations must be borne by the individual property owner.

Low cost shore protection devices are needed to reduce the rate of erosion along shorelands developed for residential use. This problem involves 11.9 miles of critically eroding shorelands along Lake Ontario. No Federal or State cost-sharing is available to help pay the $15 million cost of temporary protection.

5.6.3 Existing and Authorized Flood and Erosion Control Projects

There are five authorized beach erosion control projects on Lake Ontario. Location of authorized beach erosion control projects and studies are listed below:

(1) Lake Ontario, South Shore, New York, Resolution

(2) Fourmile Creek, New York, Resolution

(3) Golden Hill State Park, New York, Resolution

(4) Durand-Eastman Park, New York, Resolution

TABLE 12-24 Existing and Projected Shoreland Use—Lake Ontario

Shoreland Use	Miles of Shoreline 1970	1980	2000	2020
Industrial, Commercial, Public Buildings, and Lands	23	24	25	28
Residential	127	134	194	207
Public Parks, Recreation	30	30	39	39
Fish and Wildlife	0	0	0	0
Agriculture, Forest, and Undeveloped	110	102	32	16
Total	290	290	290	290

TABLE 12-25 Existing and Projected Shoreland Damages—Lake Ontario, in thousands of dollars

Land Use	Potential Single Year Damages 1966	1980	2000	2020
Industrial, Commercial, Public Buildings, and Lands	190	37	-----	-----
Residential	12,660	27,807	54,532	98,571
Public Parks, Recreation	593	630	-----	-----
Agriculture, Forest, and Undeveloped	14	9	-----	-----
Total	13,457	28,483	54,532	98,571

5.6.4 Possible Methods of Reducing Flood and Erosion Damages

Lake Ontario shoreland damages are expected to increase eightfold in the next 50 years from approximately $12 million in 1970 to $98 million in 2020. Sixty percent of the projected damage will be to existing development, while 40 percent will affect new development. Damages could be reduced by land management control over new development, structural protection, and additional lake regulation.

Section 6

A STRATEGY FOR SHORELAND DAMAGE REDUCTION

6.1 Introduction

Several alternatives are available to reduce erosion and flooding damages and the resulting losses and hardship:

(1) further lake regulation to reduce high levels

(2) structural protection against erosion and flooding, both permanent and temporary

(3) regulatory action to modify or avoid any construction in navigable waters that tends to aggravate erosion and flooding

(4) remedial measures to modify improperly designed navigation works and repair accumulated damages

(5) zoning and structural setback requirements to prevent further development on vulnerable shorelands

(6) acquisition and relocation of development from vulnerable shorelands

(7) insurance against or reimbursement from other sources for damage from erosion and flooding

No single alternative will greatly reduce losses, but a combination of all engineering and public policy measures could reduce the problem in time.

The estimated cost of a shoreland damage reduction program consisting of three phases, initial planning, immediate action, and sustained action, is approximately $5 million.

6.2 Erosion Rate and Shore Processes Study

The first part of the strategy, a systematic and comprehensive erosion rate study of the Great Lakes shorelands would compile historic erosion rates for the entire shoreland on a priority basis. Study criteria would include economic value, pollution effects of erosion (soil types), rate of erosion, and the desires of State and local government. Long-term quantitative data on the erosion rate of a bluff or dune may be obtained from early surveys and plot maps containing survey points and a plot of the bluff line and shoreline as of the date of the survey. Using these data a new topographic map can be prepared showing the historic and present locations of the bluff and shoreline. The distance between the old and existing location documents the amounts of bluff or dune recession during the period.

This part of the strategy also involves developing and analyzing information on the dynamics of the beach profile zone under various lake level and storm conditions, and investigating the effects that engineering works have on shore processes. The study has the following goals:

(1) develop wave forecasting techniques for the Great Lakes

(2) obtain wind velocity vs. duration curves (over water) for specific locations on the Great Lakes

(3) develop wave forecasting techniques for shallow water with discontinuities

(4) develop wave forecasting techniques for shorewide water bodies

(5) develop methods and techniques for flushing harbors to improve water quality (dilution aspects of dissolved solids)

(6) develop methods for determining current patterns in existing harbors

(7) develop methods for predicting current patterns of proposed harbor configurations

(8) develop methods for predicting transmissibility of pollutants from sediments to water

(9) develop methods for minimizing shoaling at harbor entrances

(10) develop methods for determining impact of coastal structures on littoral transport

(11) develop methods for predicting effect of currents on shoaling

(12) develop methods for predicting effect of short-period water level fluctuation on design of harbors

(13) develop methods for predicting short period water surface fluctuations at specific locations on the shoreline of the Great Lakes (in real time or on a statistical basis)

(14) develop techniques for predicting effect of coastal structures on adjacent shorelines, i.e., accretion, erosion, and

environmental effects

(15) develop methods for predicting amount and direction of littoral transport with depth along specific segments of the Great Lakes shoreline

(16) develop methods and techniques for beach nourishment by permanent or portable sand bypassing equipment

(17) develop techniques for determining effects of ship waves, water level fluctuations, and currents on shoreline erosion in connecting channels

(18) develop predictive techniques for shoaling in connecting navigation channels and in harbors

(19) determine gradation and quantity of sand in offshore areas of the Great Lakes (sand would be used for beach restoration and nourishment, if suitable)

This information would support the Great Lakes States in their implementation of shoreland management legislation stipulating that high-risk erosion areas be identified and delineated, and that land use controls be implemented by local governments. To be legally defensible, regulatory controls must be based on sound engineering and scientific data. The general public and local officials must be informed of the necessity of such controls and the procedures of implementation. These land-use regulations, aimed at the 1,460 miles of undeveloped erodible Great Lakes shorelands are of little use to developed areas that are already suffering erosion and flooding damages.

6.3 Shore Protection Study

The second part of the strategy is intended to assist already developed areas by arresting the loss of shoreland resources with the construction of shore protection. The plan consists of technical reports describing alternative low-cost shore protection plans, their advantages, disadvantages, and costs. The elements of this study include an assessment of the effectiveness of demonstration projects and existing shore protection measures, a public education program, and a planning assistance program.

The strategy includes demonstration projects and inventories of existing shore protection measures in order to investigate and evaluate low-cost means of controlling erosion. The public education program could consist of monies for shore protection structures, and speaker bureaus of specialists available to give slide presentations and distribute general publications on coastal engineering problems and solutions. Planning assistance should be made available to local communities developing comprehensive shore protection plans for highly developed shoreland areas, including both public and private property. Additional legislation is needed to implement the elements of this part of the strategy.

6.4 Data Collection

The third part of the strategy is concerned with the collection of relevant economic, social, and environmental data. The lack of sound planning information is a major constraint to comprehensive shoreland management. Information on the shoreland zone has not been systematically collected or made available to the public. This study would develop a planning framework of data on shore damages, social values, and ecosystem relationships that are relevant in the shoreland zone. Inventory and display of technical information on coastal resouces are essential to sound management of the coastal zone. The information would be published on large scale maps and distributed to local public officials and special interest groups. The following would be elements of this study:

(1) Documentation of erosion damages resulting from the 1973–1974 high-water period on the Great Lakes should have a high priority. This survey must be accomplished early to obtain reliable information.

(2) Regional planning guidelines should be developed for the shoreland zone.

(3) Resource values should be assessed from the standpoint of economic, social, aesthetic, and biological anaylsis.

(4) Actual use and perceived values of the shoreland environment should be determined.

(5) A resource value structure for the shoreland zone for impact assessment and planning evaluation should be established.

(6) Baseline environmental inventories should be conducted.

(7) Important environmental parameters and values should be tabluated.

(8) Areas of high biological productivity should be located.

(9) The biological elements contained in the zone and the rate of their relative sensitivity to change should be determined by a sensitivity analysis.

(10) An inventory of the full extent of shoreland management problems should be

taken. This inventory should include waterfront blight and shoreland alterations.

Immediate action should include:

(1) initial inventory of shoreland damage and an assessment of protective measures

(2) continuation of extraordinary regulation procedures for Lake Superior and Lake Ontario to provide maximum relief from critical high water levels without causing undue detriment to Lake Superior or St. Lawrence River interests

(3) completion of emergency flood protection with assistance under Public Law 99 in advance of the fall storm period

(4) accelerated execution of authorized Federal shoreland protection projects

(5) pilot projects to use spoil from maintenance dredging for shoreland protection

(6) further protective measures by State and local governments with appropriate technical Federal support

(7) expanded efforts by private owners to provide erosion protection with technical assistance from Federal, State, and local governments

(8) expansion of disaster insurance coverage

(9) efforts to obtain authority at each level of government consistent with roles agreed upon in strategy development including nonessential and conflicting uses, historic preservation, wetland encroachment, unplanned development, public access, and sedimentation. Environmental information should be mapped in sufficient detail for its use in future planning, and should include plan formulation, project design, maintenance, dredging, and environmental impact assessment.

Initial planning should include:

(1) consultation among Federal and State agencies with inter-governmental bodies, including the Federal Regional Council and the Great Lakes Basin Commission, to define the organizational framework for better communications and closer cooperation on shoreland damage reduction

(2) a conference of senior Federal and State officials to consider the concept for strategy development and implementation

(3) a series of workshops and review meetings to amplify and refine the strategy with particular attention to

(a) definition of alternative courses of action

(b) roles of Federal, State, and local governments

(c) requirements for additional knowledge and data

(d) priorities and resources for action programs

Sustained action should include:

(1) continual updating of the strategy to insure an optimum mix of programs for reducing shoreland damage (This will require continued comprehensive analysis of technical, economic, environmental, and social factors.)

(2) expansion of technical knowledge and specific data for use by officials who decide on the strategy and on specific programs to carry it out

(3) completion of international studies on further lake regulation, a joint decision by the United States and Canada on whether to proceed with any proposed project, and construction of any regulatory works that may be authorized pursuant to such a decision

(4) study, recommendation, authorization, and execution of permanent shoreland protection projects eligible for Federal participation under Public Laws 166 (1945), 826 (1956), and 87–874

(5) mitigation of damages from Federal navigation projects under Section 111, Public Law 90–483

(6) enactment and execution of State programs for shoreline management, with Federal assistance under Public Law 92–583

(7) enactment and execution of State and local programs for acquisition and relocation of development from vulnerable shorelands

(8) continued provision of protection against erosion and flooding by private owners with technical assistance from Federal, State, and local governments

(9) regulation of construction in navigable waters to prevent new structures and progressively modify or eliminate existing structures which tend to aggravate erosion and flooding

6.5 Conclusions

The Great Lakes Basin Commission should assign a high priority to the question of "value" accruing to the uses of shoreland areas, to regional decision-making concerning future uses and reclamation, and to the allocation of resources accompanied by priorities and vehicles for action. The Commission should offer professional advice to State and metropolitan agencies as well as endorse and support the legal and financial requirements set up by governments for planning and programming in response to social, economic, and environmental interests within a regional framework.

GLOSSARY

accretion—natural accretion is the gradual build-up of land on a beach by deposition of water- or air-borne material. Artificial accretion is a similar build-up of land because of a groin, breakwater, or beach fill.

agriculture and undeveloped lands—this type of shoreland use includes croplands, pasturelands, and all vacant and undeveloped lands except forests and wooded areas.

artificial nourishment—the process of rebuilding a beach by the replenishment of beach materials by artificial means such as the deposition of dredge spoil.

artificial shore type—an area of the shoreland that has been artificially modified by man through the placement of structures, by filling, or by dredging so that the original natural shoreline no longer exists.

backshore—that zone of the shore or beach, lying landward of the foreshore, that is usually dry and only affected by wave action generated by severe storms.

barrier beach—a bar formed from bottom materials lying parallel to the shore, the crest of which is above high water.

beach—a shoreland zone of unconsolidated material that extends landward from the shoreline to the place where there is a marked change in material or physiographic form or to the line of permanent vegetation. The lakeward limit of a beach includes the foreshore and backshore.

beach berm—a nearly horizontal portion of the beach or backshore formed by the deposit of material by wave action. Some beaches have no berms, others have one or several.

beach erosion—the carrying away of beach materials by wave action, tidal currents, littoral currents, or winds.

berm—a low, relatively flat beach lying between the landward limit of the backshore and the lakeward limit of the bordering upland shore.

bluffs—a high, steep bank or cliff. For the purposes of this study bluffs have been classified as:

a high bluff, 30 feet above the shoreline or higher and composed of erodible materials (HBE)

a high bluff, 30 feet above the shoreline or higher and composed of nonerodible materials (HBN)

a low bluff, less than 30 feet high and composed of erodible materials (LBE)

a low bluff, less than 30 feet high and composed of nonerodible materials (LBN)

breakwater—a structure for breaking the force of waves to protect craft anchored in a harbor or to protect a beach from erosion. An offshore barrier may be either an artificial structure or a natural formation. Sometimes it is connected at one or both ends with the shore.

bulkhead—a low wall of stones, concrete or piling built to protect a shore, or fills, from wave erosion. A bulkhead may be built to protect navigable waters and serve as a line, limiting filling, or beyond which filling of submerged lands is not permitted.

coastal area—the land and sea area bordering the shoreline.

coastal line—(1) technically, the line that forms the boundary between the coast and the shore; (2) commonly, the line that forms the boundary between the land and the water.

commercial—this type of shoreland use generally includes buildings, parking areas, and other uses directly related to retail and wholesale trade and business and professional services. Examples of commercial land uses are stores, gas stations, motels, marinas, professional buildings, and restaurants.

conservation district contour—(1) a line connecting the points on a land or submarine surface that have the same elevation; (2) in topographic or hydrographic work, a line connecting all points of equal elevation above or below a datum plane.

crest length, wave—the length of a wave along its crest, sometimes called crest width.

crest of wave—(1) the highest part of a wave; (2) that part of the wave above still water level.

current, coastal—one of the offshore currents flowing generally parallel to the shore line with a relatively uniform velocity (as compared to the littoral currents). They are not related generically to waves and resulting surf but may be composed of currents related to distribution of mass in lake waters and wind-driven currents.

current, littoral—the nearshore currents primarily due to wave action, e.g., longshore currents and rip currents.

dike—a wall or mound built around a low-lying area to prevent flooding.

downdrift—the predominant direction of movement of littoral materials.

drift—(1) the current's speed; (2) floating material deposited on a beach (driftwood); (3) a deposit left by a continental ice sheet, like a drumlin; (4) sometimes used as an abbreviation of littoral drift.

dunes—ridges, mounds or hills of loose, windblown material, usually sand. Stable dunes are those which are covered with vegetation and generally not readily susceptable to erosion by wind or water runoff. Unstable dunes are those which are bare of vegetation and subject to movement or erosion by both wind and water. For the purposes of this study, dunes have been classified as high dunes, stable or unstable, rising 30 feet or higher above the shoreline (HD), and low dunes, stable or unstable, less than 30 feet above the shoreline (LD)

environmental areas—areas of the shorelands both upland and offshore, which provide habitat for fish, wildlife and other aquatic life, contain unique populations of flora and fauna, or are otherwise ecologically significant.

erosion—the wearing away of the land by the action of wind, water, gravity, or a combination thereof. Shoreland erosion on the Great Lakes is most often a result of a combination of (a) wind-driven waves beating upon the shore and forming littoral currents, and (b) high water levels.

fetch—in wave forecasting, the continuous area of water over which the wind blows in essentially a constant direction. Sometimes used synonymously with fetch length.

fetch length—in wave forecasting, the horizontal distance (in the direction of the wind) over which the wind blows.

fish and game lands—this type of land use consists of all land areas managed for fish and game production, including wildlife and game preserves.

foreshore—that zone of the shore or beach lying landward of the shoreline that is usually wet and directly affected by all wave action.

forest—this land use consists of all public and private forested areas or woodlands which are not designated as recreational lands.

free-board—additional height of a structure above design high water level to prevent overflow. Also, at a given time the vertical distance between the water level and the top of the structure. On a ship, the distance from the water line to main deck or gunwale.

gabion—a specifically designed basket or box of corrosion-resistant wire used to hold rock and other course aggregate. Gabions may be locked together to form groins, seawalls, revetments, deflectors, breakwaters, and other protective structures for erosion control. Their flexible construction permits minor adjustments of alignment resulting from undercutting, filling, and settling.

general use district geomorphology—that branch of both physiography and geology which deals with the form of the earth, the general configuration of its surface, and the changes that take place in the evolution of land forms.

Great Lakes Basin—the hydrographic area defined by the drainage areas of Lake Superior, Lake Michigan, Lake Huron, Lake Erie, Lake Ontario, and the St. Lawrence Seaway to the Canadian-New York International Boundary Line, and including all closed basins within the topographic divides separating the Great Lakes Basin from adjacent major drainages.

Great Lakes Region—the approximate boundary of the Great Lakes Basin defined by selected county lines for statistical data availability and economic analysis.

groin—a shore protective structure usually built perpendicular to the shoreline to trap littoral drift or retard erosion of the shore. It is narrow in width and its length may vary from less than one hundred to several hundred feet (extending from a point landward of the shoreline out into the water). Groins may be classified as permeable or impermeable and may be manufactured of wood, concrete, or steel. Impermeable groins have a solid or nearly solid structure. Permeable groins contain openings of sufficient size to permit passage of large quantities of littoral drift.

height of wave—the vertical distance between the crest and the preceding trough.

high water line—the intersection of the plane of mean high water with the shore. The shoreline delineated on the nautical charts of the Coast and Geodetic Survey is an approximation of the mean highwater line.

industrial—this type of land use includes all industrial buildings, parking areas, adjacent yards, and landscaped grounds. Included are warehousing, mining, and other extractive industries, manufacturing industries, steel mills, private utilities, and railroad facilities.

jetty—used synonymously with groins on ocean sea coasts, jetties are designed to prevent shoaling by littoral materials in channels. They are often constructed at the mouth of a river or tidal inlet to help deepen and stabilize the channel.

levee—a dike or embankment for the protection of land from inundation.

littoral—pertains to the shore, including the shoreland, shore waters, and nearshore bottom of a lake.

littoral deposits—deposits of littoral drift.

littoral drift—the bottom materials moved in the littoral zone under the influence of waves and current. Direction of movement or "transport" of littoral material depends upon wind and wave direction.

littoral transport—the movement of material along the shore in the littoral zone by waves and currents.

low water datum—an approximation to the plane of mean low water that has been adopted as a standard reference plane.

nodal-zone—an area in which the predominant direction of the littoral transport changes.

offshore—in beach terminology, the comparatively flat zone of variable width, extending from the breaker zone to the seaward edge of the continental shelf.

pile—a long, slender piece of wood, concrete, or metal to be driven or jetted into the earth or sea bed to serve as a support or protection.

pile, sheet—a pile with a generally flat cross-section to be driven into the ground or sea bed and meshed or interlocked with like members to form a diaphragm, wall, or bulkhead.

plain—a low-lying, relatively flat shoreland which extends several hundred feet landward from the shoreline. For the purposes of this study, plains have been identified as a low plain consisting of erodible shoreland materials (PE), and a low plain consisting of nonerodible shoreland materials (PN).

preservation district profile, beach—the intersection of the ground surface with a vertical plane; may extend from the top of the dune line to the lakeward limit of sand movement.

public buildings and related lands—this shoreland use includes all buildings and related grounds belonging to public or quasi-public agencies, governments, or organizations.

This would encompass medical facilities, educational facilities, religious institutions, governmental administration and service buildings, military installations, water and sewage treatment plants, and airports.

recreation and other urban public use space—this shoreland use contains all designated public outdoor recreation lands and associated facilities. Privately owned outdoor recreation lands such as golf courses, tennis clubs, amusement parks, and race tracks are included. Cemeteries have been placed in this category as well.

residential—residential shoreland use has been defined to include four or more single or multi-family dwelling units adjacent to each other. Also included within this category are churches, elementary schools, small neighborhood parks, and small isolated commercial buildings, such as a neighborhood grocery store, within the boundaries of the residential area.

revetment—a facing of stone, concrete, etc., built to protect a scarp, embankment, or shore structure against erosion by the wave action or currents.

riprap—a layer, facing, or protective mound of stones randomly placed to prevent erosion, scour, or sloughing of a structure or embankment, also, the stone so used.

rubble-mound structure—a mound of randomly shaped and randomly placed stones protected with a cover layer of selected stones or specially shaped concrete armor units. Armor units in primary cover layer may be placed in orderly manner or dumped at random.

run-up—the rush of a breaking wave up a structure. The amount of run-up is the vertical height above still water level that the water reaches.

seawall—a structure separating land and water areas primarily designed to prevent erosion and other damage due to wave action.

seiche—a periodic, rapid, and often violent fluctuation or oscillation of the water level of a lake most often caused by winds and barometric pressure. A seiche often occurs after a prolonged period of strong winds from the same direction which causes the water of a lake to pile up on its windswept side. Seiches can cause water level fluctuations in the Great Lakes of up to eight feet that may result in serious flooding or damage to the adjacent shorelands.

set-up, wind—(1) the vertical rise in the still water level on the leeward side of a body of water caused by wind stresses on the surface of the water, (2) one-half of the difference in still water level between the windward and the leeward sides of a body of water caused by wind stresses on the surface of the water.

shore—a strip of land bordering any body of water. A shore of unconsolidated materials is usually called a beach.

shorelands—those lands, waters, and submerged lands in close proximity to the shoreline of the Great Lakes. Included, for the purposes of the study, are uplands extending one-half mile landward of the shoreline and bottom lands and waters extending two miles lakeward of the shoreline.

shorelines—the line forming the intersection of the water with the shore. The location of this line, of course, will vary depending upon the water levels of the Great Lakes.

shoreline protection—structural measures designed for placement along the shore to relieve erosion and flooding damages. Examples of structural measures are protective beaches, seawalls, groins and revetments.

shore type—the character of the shoreland immediately adjacent to the shoreline based on height, composition, and erodibility. Shoretypes used in this study are low plain, high bluff, low bluff, high dune, low dune, wetlands, and artificial.

significant wave—a statistical term denoting waves with the average height and period of the one-third highest waves of a given wave group. The composition of the higher waves depends upon the extent to which the lower waves are considered. Experience so far indicates that a careful observer who attempts to establish the character of the higher waves will record values which approximately fit the definition. A wave of significant wave period and significant wave height.

significant wave height—the average height of the one-third highest waves of a given wave group. Note that the composition of the highest waves depends upon the extent to which the lower waves are considered. In wave record analysis, the average height of the highest one-third of a selected number of waves, this number being determined by dividing the time of record by the significant period.

significant wave period—an arbitrary period generally taken as the period of the one-third highest waves within a given group. Note that the composition of the highest waves depends upon the extent to which the lower waves are considered. In wave record analysis, this is determined as the average period of the most frequently recurring of the larger, well-defined waves in the record under study.

slope—the degree of inclination to the horizontal. Usually expressed as a ratio, such as 1:25 or 1 on 25, indicating 1 unit rise in 25 units of horizontal distance; or in a decimal fraction (0.04); degrees (2° 18′); or percent (4%). It is sometimes described as steep, moderate, gentle, mild, or flat.

still water level—the elevation of the surface of the water if all wave action were to cease.

topography—the configuration of a surface including its relief, the position of its streams, roads, buildings, etc.

updrift—the direction opposite that of the predominant movement of littoral materials.

uprush—the rush of water up onto the beach following the breaking of a wave.

wave crest—the highest part of a wave. Also that part of the wave above still water level.

wavecrest length—the length of a wave along its crest. Sometimes called crest width.

wave height—the vertical distance between a crest and the preceding trough.

wave length—the horizontal distance between similar points on two successive waves measured perpendicularly to the crest.

wetlands—relatively flat lands, either covered by water or waterlogged, that are wet during all or part of the year. These lands are generally characterized by grasses, shrubs, cattails, bulrushes, and other low growing plants. Along the Great Lakes shoreline they include marshes, swamps, and other lands generally considered to be potential fish and wildlife areas.

wind set-up—(1) the vertical rise in the still water level on the leeward side of a body of water caused by wind stresses on the surface of the water; (2) one-half of the difference in still water levels on the windward and the leeward sides of a body of water caused by wind stresses on the surface of the water.

windswept shore—the unprotected shore that receives the full effect of prevailing wind and waves. The greatest erosion problem areas on the Great Lakes are found along the windswept shore.

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Attachment A

INVENTORY OF GREAT LAKES ISLANDS

This attachment contains tables describing islands of the Great Lakes. The source of these data is the report *Islands of America* by the U.S. Department of Interior, Bureau of Outdoor Recreation.

TABLE 12–26 Inventory of Major Island Groups of Lake Superior and St. Marys River

Island Group	State	County	Public Acreage	Private Acreage	Percent Developed	Access	Physical Characteristics Topography	Cover	Shoretype
Isle Royale	Mich.	Keweenaw	133,844	0	1–25	No	NA	NA	NA
Apostle Islands									
Manitou Island	Wis.	Ashland	47	1,316	----	No	100% Rolling	100% Forest	100% Bluff
Rocky Island	Wis.	Ashland	-----	1,094	0	No	100% Rolling	100% Forest	100% Bluff
Bear Island	Wis.	Ashland	-----	1,824	1–25	No	100% Rolling	100% Forest	100% Bluff
South Twin Island	Wis.	Ashland	-----	360	0	No	100% Rolling	100% Forest	5% Beach 95% Bluff
Madeleine Island	Wis.	Ashland	947	14,315	1–25	No	100% Rolling	62% Forest 8% Swamp 5% Cultivated 25% Developed	15% Beach 85% Bluff
Michigan Island	Wis.	Ashland	49	1,529	1–25	No	100% Rolling	100% Forest	5% Beach 95% Bluff
Cat Island	Wis.	Ashland	59	1,281	0	No	100% Rolling	100% Forest	100% Bluff
Devils Island	Wis.	Ashland	318	-----	0	No	100% Rolling	100% Forest	100% Bluff
Ironwood Island	Wis.	Ashland	-----	659	0	No	100% Rolling	100% Forest	100% Bluff
Long Island	Wis.	Ashland	-----	408	0	No	100% Level	100% Forest	100% Bluff
Outer Island	Wis.	Ashland	279	7,720	0	No	100% Rolling	100% Forest	100% Bluff
Basswood Island	Wis.	Ashland	603	1,378	0	No	100% Rolling	100% Forest	100% Bluff
Oak Island	Wis.	Ashland	4,971	107	0	No	100% Rolling	100% Forest	100% Bluff
Stockton Island	Wis.	Ashland	9,874	180	0	No	100% Rolling	100% Forest	5% Beach 95% Bluff
Otter Island	Wis.	Ashland	-----	1,332	0	No	100% Rolling	100% Forest	100% Bluff
North Twin Island	Wis.	Ashland	-----	175	0	No	100% Rolling	100% Forest	100% Bluff
Hermit Island	Wis.	Ashland	-----	778	0	No	100% Rolling	100% Forest	100% Bluff
Raspberry Island	Wis.	Bayfield	295	-----	26–50	No	NA	NA	NA
York Island	Wis.	Bayfield	-----	321	0	No	90% Level 10% Rolling	2% Grass 83% Forest 15% Swamp	40% Beach 60% Bluff
Sand Island	Wis.	Bayfield	201	2,747	1–25	No	75% Level 25% Rolling	NA	NA
Eagle Island	Wis.	Bayfield	2	26	0	No	NA	NA	NA
Huron Islands									
Middle Island	Mich.	Marquette	11	0	0	No	NA	NA	NA
Lighthouse Island	Mich.	Marquette	40	0	1–25	No	100% Mountain	90% Forest 10% Barren	100% Bluff
Gull Island	Mich.	Marquette	15	0	0	No	NA	NA	NA
East Huron Island	Mich.	Marquette	80	0	0	No	NA	NA	NA
Grand Islands									
Grand Island	Mich.	Alger	110	12,795	1–25	Yes	100% Level	88% Forest 10% Swamp 2% Barren	8% Beach 92% Bluff
Au Train Island	Mich.	Alger	0	105	0	No	100% Rolling	100% Forest	100% Bluff
Wood Island	Mich.	Alger	0	170	0	Yes	100% Rolling	100% Forest	100% Bluff
Williams Island	Mich.	Alger	0	33	0	No	100% Rolling	100% Forest	100% Bluff
St. Marys River									
Neebish Island	Mich.	Chippewa	650	400	26–50	No	50% Level 50% Rolling	40% Grass 60% Forest	40% Beach 40% Bluff 20% Swamp
Sugar Island	Mich.	Chippewa	5,000	12,331	26–50	Yes	100% Rolling	15% Forest 75% Shrub 10% Cultivated	40% Beach 40% Bluff 20% Swamp
Lime Island	Mich.	Chippewa	NA	NA	NA	NA	NA	NA	NA

NA--Not applicable

TABLE 12–27 Inventory of Major Island Groups of Lake Michigan

Island Group	State	County	Public Acreage	Private Acreage	Percent Developed	Access	Physical Characteristics		
							Topography	Cover	Shoretype
Summer Islands									
Gull Island	Mich.	Delta	0	13	0	No	100% Rolling	100% Forest	100% Beach
Little Gull Island	Mich.	Delta	0	10	0	No	100% Rolling	100% Forest	100% Beach
Poverty Island	Mich.	Delta	0	192	1-25	No	100% Rolling	100% Forest	100% Bluff
Rocky Island	Mich.	Delta	0	10	0	No	100% Rolling	100% Forest	100% Beach
St. Martin Island	Mich.	Delta	34	1,288	1-25	No	30% Level 60% Rolling 10% Mountain	90% Forest 5% Swamp 5% Barren	20% Beach 80% Bluff
Summer Island	Mich.	Delta	1,065	0	1-25	No	100% Rolling	100% Forest	100% Bluff
Little Summer Island	Mich.	Delta	90	416	0	No	100% Rolling	100% Forest	100% Bluff
Green Bay Islands									
Chambers Island	Wis.	Door	40	2,760	0	No	100% Rolling	2% Grass 86% Forest 10% Water 2% Developed	100% Bluff
Detroit Island	Wis.	Door	0	680	0	No	100% Rolling	99% Forest 1% Barren	90% Beach 10% Bluff
Washington Island	Wis.	Door	148	15,552	51-75	No	100% Level	15% Grass 50% Forest 1% Swamp 30% Cultivated 4% Developed	75% Beach 20% Bluff 5% Other
Rock Island	Wis.	Door	906	0	0	No	NA	NA	NA
Manitou Islands									
North Manitou Island	Mich.	Leelenau	0	14,100	1-25	No	15% Level 85% Rolling	15% Grass 75% Forest 10% Barren	40% Beach 60% Bluff
South Manitou Island	Mich.	Leelenau	2,940	2,000	1-25	No	30% Level 70% Rolling	15% Grass 85% Forest	100% Bluff
Fox Islands									
North Fox Island	Mich.	Leelenau	NA	NA	1-25	No	20% Level 80% Rolling	15% Grass 85% Forest	100% Bluff
South Fox Island	Mich.	Leelenau	500	2,882	1-25	No	30% Level 70% Rolling	5% Grass 90% Forest 5% Other	100% Bluff
Beaver Islands									
Beaver Island	Mich.	Charlevoix	7,093	28,372	1-25	No	NA	65% Forest 10% Swamp 10% Barren 5% Water 10% Developed	80% Beach 10% Bluff 10% Swamp
Gull Island	Mich.	Charlevoix	240	0	0	No	40% Level 60% Rolling	80% Forest 10% Barren 10% Other	90% Beach 10% Bluff
Trout Island	Mich.	Charlevoix	-----	-----	1-25	No	40% Level 60% Rolling	80% Forest 20% Barren	80% Beach 20% Bluff
High Island	Mich.	Charlevoix	3,510	0	0	No	30% Level 50% Rolling 20% Mountain	75% Forest 8% Swamp 5% Barren 2% Water 10% Other	10% Beach 90% Bluff
Whiskey Island	Mich.	Charlevoix	0	96	1-25	No	40% Level 60% Rolling	90% Forest 5% Barren 5% Other	80% Beach 20% Bluff
Squaw Island	Mich.	Charlevoix	0	69	1-25	No	75% Level 25% Rolling	90% Forest 5% Barren 5% Other	70% Beach 30% Bluff
Garden Island	Mich.	Charlevoix	4,154	218	0	No	50% Level 50% Rolling	80% Forest 8% Swamp 10% Barren 2% Water	80% Beach 20% Bluff
Hog Island	Mich.	Charlevoix	1,864	207	0	No	NA	NA	NA
Hat Island	Mich.	Charlevoix	0	11	0	No	60% Level 40% Rolling	90% Forest 8% Swamp 2% Barren	90% Beach 10% Bluff
Fisherman Island	Mich.	Charlevoix	0	15	0	No	--	--	--
Waugoshance Islands									
Waugoshance Island	Mich.	Emmet	100	0	0	No	100% Level	60% Forest 20% Shrub 10% Swamp 10% Barren	NA
Temperance Island	Mich.	Emmet	100	0	0	No	100% Level	20% Forest 40% Shrub 30% Swamp 10% Barren	50% Beach 50% Bluff
No Name	Mich.	Emmet	30	0	---	No	NA	NA	NA

NA--Not applicable

TABLE 12–28 Inventory of Major Island Groups of Lake Huron

Island Group	State	County	Public Acreage	Private Acreage	Percent Developed	Access	Physical Characteristics Topography	 Cover	Shoretype
Potagannising Islands									
James Island	Mich.	Chippewa	0	26	1–25	No	100% Rolling	5% Grass 85% Forest 10% Developed	20% Beach 80% Bluff
Rutland Island	Mich.	Chippewa	0	73	0	No	100% Rolling	100% Forest	100% Bluff
Peck Island	Mich.	Chippewa	0	40	1–25	No	100% Rolling	93% Forest 2% Shrub 5% Water	100% Bluff
Ashman Island	Mich.	Chippewa	0	62	0	No	100% Rolling	10% Grass 90% Forest	100% Bluff
LaPointe Island	Mich.	Chippewa	0	23	1–25	No	100% Rolling	75% Forest 25% Shrub	100% Bluff
Grape Island	Mich.	Chippewa	0	80	1–25	No	100% Rolling	96% Forest 2% Water 2% Developed	100% Bluff
Rugg Island	Mich.	Chippewa	0	29	0	No	100% Rolling	80% Forest 10% Shrub 10% Water	100% Bluff
Bald Island	Mich.	Chippewa	0	75	1–25	No	100% Rolling	99% Forest 1% Developed	100% Bluff
Boulanger Island	Mich.	Chippewa	0	46	1–25	Yes	100% Rolling	94% Forest 6% Swamp	100% Bluff
Harbor Island	Mich.	Chippewa	0	694	0	No	100% Rolling	2% Grass 90% Forest 8% Swamp	65% Bluff 35% Swamp
Standerson Island	Mich.	Chippewa	0	20	0	No	100% Rolling	---	---
Cedar Island	Mich.	Chippewa	0	64	0	No	100% Rolling	90% Forest 10% Shrub	100% Bluff
Wilson Island	Mich.	Chippewa	0	159	0	No	100% Rolling	10% Grass 80% Forest 10% Shrub	15% Beach 85% Bluff
Strickland Island	Mich.	Chippewa	0	30	26–50	No	100% Level	100% Forest	---
Gull Island	Mich.	Chippewa	0	16	0	No	100% Rolling	50% Forest 50% Swamp	100% Swamp
Saltonstall Island	Mich.	Chippewa	0	19	0	No	100% Level	95% Forest 5% Barren	100% Bluff
Long Island	Mich.	Chippewa	0	17	0	No	100% Rolling	10% Grass 90% Forest	100% Bluff
Harris Island	Mich.	Chippewa	0	11	0	No	100% Level	70% Forest 30% Swamp	100% Bluff
Claw Island	Mich.	Chippewa	0	10	0	No	100% Level	NA	100% Bluff
Burnt Island	Mich.	Chippewa	0	NA	1–25	No	100% Rolling	10% Grass 60% Forest 5% Shrub 25% Swamp	20% Beach 80% Bluff
Maple Island	Mich.	Chippewa	0	123	1–25	No	100% Rolling	99% Forest 1% Developed	100% Bluff
Butterfield Island	Mich.	Chippewa	0	32	1–25	No	60% Level 40% Rolling	5% Grass 95% Forest	100% Bluff
Big Trout Island	Mich.	Chippewa	0	94	1–25	No	100% Rolling	100% Forest	100% Bluff
Macomb Island	Mich.	Chippewa	0	240	1–25	No	50% Level 50% Rolling	2% Grass 96% Forest 2% Shrub	100% Bluff
Andrews Island	Mich.	Chippewa	0	14	76–100	No	NA	70% Forest 5% Shrub 20% Barren 5% Developed	NA
Cass Island	Mich.	Chippewa	0	74	1–25	No	100% Level	60% Forest 5% Shrub 35% Barren	10% Beach 90% Bluff
Pipe Island	Mich.	Chippewa	0	13	76–100	No	100% Level	60% Forest 10% Shrub 20% Barren 10% Developed	100% Beach
Saginaw Bay Islands									
South Mineshas Island	Mich.	Huron	0	100	0	Yes	---	---	---
North Mineshas Island	Mich.	Huron	14	0	0	Yes	---	---	---
Katechay Island	Mich.	Huron	885	0	0	No	---	---	---
Stony Island	Mich.	Huron	387	0	0	Yes	100% Level	---	42% Beach 42% Bluff 16% Swamp
North Island	Mich.	Huron	0	88	1–25	No	100% Level	90% Forest 10% Developed	30% Beach 70% Bluff
Charity Island	Mich.	Arenac	0	280	0	No	---	75% Forest 20% Shrub 4% Barren 1% Water	100% Bluff
Little Charity Island	Mich.	Arenac	0	17	0	No	---	5% Forest 75% Shrub 20% Barren	100% Bluff

NA--Not available

TABLE 12-28(continued) Inventory of Major Island Groups of Lake Huron

			Public	Private	Percent		Physical Characteristics		
Island Group	State	County	Acreage	Acreage	Developed	Access	Topography	Cover	Shoretype
Drummond Islands									
Drummond Island	Mich.	Chippewa	47,395	33,569	1-25	No	25% Level 75% Rolling	15% Grass 65% Forest 10% Shrub 10% Swamp	50% Beach 50% Bluff
Shelter Island	Mich.	Chippewa	0	70	0	No	100% Level	60% Forest 30% Shrub 10% Barren	100% Bluff
Meade Island	Mich.	Chippewa	0	160	1-25	No	100% Rolling	10% Grass 70% Forest 10% Shrub 5% Barren 5% Developed	100% Bluff
Clark Island	Mich.	Chippewa	0	10	26-50	No	NA	NA	NA
Silver Island	Mich.	Chippewa	0	10	1-25	No	NA	NA	NA
Gravel Island	Mich.	Chippewa	0	20	0	No	100% Level	40% Forest 20% Shrub 40% Barren	100% Bluff
Long Island	Mich.	Chippewa	0	40	1-25	No	100% Rolling	97% Forest 3% Developed	100% Bluff
Espanore Island	Mich.	Chippewa	0	120	1-25	No	100% Rolling	45% Forest 45% Shrub 5% Barren 5% Developed	100% Bluff
Boot Jack Island	Mich.	Chippewa	0	20	1-25	No	100% Rolling	85% Forest 5% Barren 10% Developed	100% Bluff
Garden Island	Mich.	Chippewa	0	40	0	No	100% Rolling	80% Forest 20% Shrub	100% Bluff
Bellevue Island	Mich.	Chippewa	0	30	0	No	100% Rolling	70% Forest 30% Shrub	100% Bluff
Arnold Island	Mich.	Chippewa	0	30	0	No	100% Rolling	100% Forest	100% Bluff
Bird Island	Mich.	Chippewa	0	10	0	No	NA	NA	NA
Les Cheneaux Islands									
Marquette Island	Mich.	Mackinac	200	3,800	1-25	No	100% Level	99% Forest 1% Swamp	NA
Government Island	Mich.	Mackinac	215	---	0	No	100% Level	100% Forest	100% Beach
Goose Island	Mich.	Mackinac	0	80	0	No	NA	NA	NA
Birch Island	Mich.	Mackinac	0	21	1-25	No	100% Level	99% Forest 1% Developed	100% Beach
Long Island	Mich.	Mackinac	0	70	1-25	No	100% Level	99% Forest 1% Developed	100% Beach
Little LaSalle Island	Mich.	Mackinac	0	400	1-25	No	100% Level	98% Forest 1% Swamp 1% Developed	90% Bluff 10% Swamp
Big LaSalle Island	Mich.	Mackinac	0	1,012	1-25	No	100% Level	97% Forest 2% Swamp 1% Developed	NA
Boot Island	Mich.	Mackinac	0	123	1-25	No	100% Level	95% Forest 5% Developed	100% Beach
Coryell Island	Mich.	Mackinac	0	82	26-50	No	100% Level	50% Forest 50% Developed	100% Beach
Island No. 8	Mich.	Mackinac	0	132	1-25	No	100% Level	50% Forest 50% Developed	100% Beach
Hill Island	Mich.	Mackinac	0	235	26-50	No	100% Level	60% Forest 40% Swamp	90% Beach 10% Swamp
Strongs Island	Mich.	Mackinac	0	90	1-25	No	100% Level	100% Forest	100% Beach
Whitefish Pointe Island	Mich.	Mackinac	0	31	0	No	100% Level	100% Forest	100% Beach
Rover Island	Mich.	Mackinac	0	16	1-25	No	100% Level	100% Forest	100% Beach
St. Martin Islands									
Big St. Martin Island	Mich.	Mackinac	0	951	1-25	No	100% Level	99% Forest 1% Swamp	100% Beach
Little St. Martin	Mich.	Mackinac	0	472	0	No	100% Level	99% Forest 1% Swamp	---
Mackinac Island	Mich.	Mackinac	232	2,089	51-75	No	40% Level 60% Rolling	10% Grass 75% Forest 15% Developed	100% Bluff
Round Island	Mich.	Mackinac	392	0	1-25	No	100% Rolling	100% Forest	100% Bluff
Bois Blanc Island	Mich.	Mackinac	10,676	0	26-50	No	80% Level 20% Rolling	---	15% Beach 85% Bluff
Thunder Bay Islands									
Middle Island	Mich.	Alpena	29	226	0	No	---	---	5% Beach 94% Bluff 1% Swamp
Round Island	Mich.	Alpena	0	12	0	No	---	---	---
Crooked Island	Mich.	Alpena	0	47	1-25	No	---	---	35% Beach 60% Bluff 5% Swamp
Gull Island	Mich.	Alpena	0	11	0	No	---	---	---
Sugar Island	Mich.	Alpena	0	173	0	No	---	---	90% Beach 10% Bluff
Thunder Bay Island	Mich.	Alpena	218	0	1-25	No	---	20% Grass 50% Forest 30% Shrub	70% Beach 30% Bluff
Sulphur Island	Mich.	Alpena	0	53	0	No	---	---	---

NA--Not Available

TABLE 12-29 Inventory of Major Island Groups of St. Clair River, Lake St. Clair, and Detroit River

							Physical Characteristics		
Island Group	State	County	Public Acreage	Private Acreage	Percent Developed	Access	Topography	Cover	Shoretype
St. Clair River Islands	No island groups located in this connecting waterway								
Lake St. Clair Islands									
Dickinsons Island	Mich.	St. Clair	16,000	4,000	1–25	Yes	NA	NA	NA
Harsens Island	Mich.	St. Clair	13,000	14,040	26–50	Yes	NA	NA	NA
Gull Island	Mich.	St. Clair	15	0	0	No	NA	NA	NA
Strawberry Island	Mich.	St. Clair	1,000	0	1–25	Yes	NA	NA	NA
No Name	Mich.	St. Clair	0	100	51–75	Yes	NA	NA	NA
No Name	Mich.	St. Clair	200	0	0	Yes	NA	NA	NA
No Name	Mich.	St. Clair	100	0	0	Yes	NA	NA	NA
No Name	Mich.	St. Clair	45	0	0	Yes	NA	NA	NA
Detroit River Islands									
Cibraltor Island	Mich.	Wayne	15	85	76–100	Yes	NA	NA	NA
Grosse Island	Mich.	Wayne	960	3,840	76–100	Yes	NA	NA	NA
Celeron Island	Mich.	Wayne	0	100	1–25	Yes	40% Level 60% Rolling	25% Grass 50% Shrub 25% Swamp	30% Beach 37% Bluff 33% Swamp
Horse Island	Mich.	Wayne	0	25	76–100	Yes	NA	NA	NA
Elba Island	Mich.	Wayne	0	35	76–100	Yes	NA	NA	NA
Sugar Island	Mich.	Wayne	0	40	0	Yes	75% Level 25% Rolling	100% Forest	50% Beach 50% Bluff
Round Island	Mich.	Wayne	50	0	26–50	Yes	100% Level	50% Forest 25% Shrub 25% Swamp	50% Beach 50% Swamp
Hickory Island	Mich.	Wayne	0	130	76–100	Yes	NA	NA	NA
Swan Island	Mich.	Wayne	0	40	76–100	Yes	NA	NA	NA
Calf Island	Mich.	Wayne	0	10	0	Yes	NA	NA	NA
Stony Island	Mich.	Wayne	0	123	26–50	Yes	NA	NA	NA
Elizabeth Island	Mich.	Wayne	240	0	0	Yes	NA	NA	NA
No Name	Mich.	Wayne	10	0	0	Yes	100% Level	NA	100% Beach
Hennepin Pointe	Mich.	Wayne	400	0	0	Yes	NA	NA	NA
Grassy Island	Mich.	Wayne	100	0	0	Yes	100% Level	50% Swamp 50% Other	50% Beach 50% Swamp
Zug Island	Mich.	Wayne	0	360	76–100	Yes	NA	NA	NA
Belle Island	Mich.	Wayne	200	0	1–25	Yes	100% Level	75% Forest 25% Developed	100% Beach
Sturgeon Bar	Mich.	Wayne	0	10	0	Yes	100% Level	40% Forest 30% Shrub 30% Swamp	60% Bluff 40% Swamp
No Name	Mich.	Wayne	0	40	0	Yes	100% Level	30% Shrub 70% Swamp	100% Swamp
Cherry Island	Mich.	Wayne	0	30	0	Yes	100% Level	40% Shrub 60% Swamp	100% Swamp
Hall Island	Mich.	Wayne	50	0	76–100	Yes	NA	NA	NA
Edmond Island	Mich.	Wayne	20	0	76–100	Yes	NA	NA	NA

NA--Not applicable

TABLE 12–30 Inventory of Major Island Groups of Lake Erie, the Niagara River, and Lake Ontario

Island Group	State	County	Public Acreage	Private Acreage	Percent Developed	Access	Physical Characteristics Topography	Cover	Shoretype
West Sister Island	Ohio	Lucas	85	--	0	Yes	100% Level	75% Forest	---
Put-In-Bay Islands									
Harbor Island	Ohio	Ottawa	0	45	1-25	Yes	NA	NA	NA
Johnson Island	Ohio	Ottawa	10	290	1-25	No	100% Level	5% Grass	10% Beach
								70% Forest	90% Bluff
								5% Cultivated	
								5% Developed	
								15% Other	
South Bass Island	Ohio	Ottawa	66	1,502	51-75	Yes	80% Level	30% Grass	10% Beach
							20% Rolling	20% Forest	90% Bluff
								30% Cultivated	
								20% Developed	
Rattlesnake Island	Ohio	Ottawa	0	65	26-50	Yes	70% Level	40% Grass	5% Beach
							30% Rolling	30% Forest	95% Bluff
								10% Cultivated	
								20% Developed	
Middle Bass Island	Ohio	Ottawa	0	750	51-75	Yes	100% Level	30% Grass	20% Beach
								20% Forest	80% Bluff
								10% Shrub	
								20% Cultivated	
								20% Developed	
Sugar Island	Ohio	Ottawa	0	29	26-50	Yes	NA	NA	NA
North Bass Island	Ohio	Ottawa	0	560	51-75	Yes	100% Level	20% Forest	15% Beach
								10% Swamp	85% Bluff
								60% Cultivated	
								10% Developed	
Mouse Island	Ohio	Ottawa	0	8	1-25	Yes	100% Level	90% Forest	10% Beach
								10% Developed	90% Bluff
Starve Island	Ohio	Ottawa	0	1	0	Yes	100% Level	50% Forest	50% Beach
								50% Barren	50% Bluff
Ballast Island	Ohio	Ottawa	0	14	51-75	Yes	NA	NA	NA
Green Island	Ohio	Ottawa	20	0	0	Yes	100% Level	100% Forest	10% Beach
									90% Bluff
Kelleys Island	Ohio	Erie	672	2,200	26-50	Yes	90% Level	20% Grass	10% Beach
							10% Rolling	10% Forest	90% Bluff
								10% Swamp	
								20% Cultivated	
								10% Developed	
								30% Other	
Niagara River Island									
Grand Island	N.Y.	Niagara	--	--	--	--	---	---	---
Grenadier-Fox-Litt	N.Y.	Jefferson	NA	NA	1-25	No	100% Level	40% Forest	50% Beach
								20% Swamp	40% Bluff
								40% Barren	10% Swamp
Galloo Island	N.Y.	Jefferson	NA	NA	NA	NA	NA	NA	NA
Stony Island	N.Y.	Jefferson	0	1,422	1-25	No	100% Level	60% Forest	80% Beach
								2% Swamp	20% Bluff
								38% Barren	

NA--Not applicable

Attachment B

INVENTORY OF GREAT LAKES SHORELAND RESOURCES

This attachment contains maps and summary tables describing the shorelands of the Great Lakes.

The symbols on the maps indicate the physical description of the shorelands, ownership, use, reaches with erosion and flooding problems, environmental values, critical bird nesting areas, and migration routes. Water intakes and waste outfalls are also noted.

The tables support and further describe the data shown on the maps. Tables 12–31 through 12–45 aggregate the evaluated factors by individual planning subareas. Table 12–46, which contains information on critical bird nesting areas and migration routes, is to be used with the set of color maps in the back of the volume. The county entries on the table are identical to the color map titles, and they appear in the same order. The map location numbers in the table appear on the color maps.

List of Maps

Shorelands of the Great Lakes, Cook County, Minnesota
Shorelands of the Great Lakes, Carlton, St. Louis, Lake Counties, Minnesota
Shorelands of the Great Lakes, Iron, Ashland, Bayfield, Douglas Counties, Wisconsin
Shorelands of the Great Lakes, Ontonagon, Gogebic Counties, Michigan
Shorelands of the Great Lakes, Baraga, Houghton, Keweenaw Counties, Michigan
Shorelands of the Great Lakes, Marquette, Alger Counties, Michigan
Shorelands of the Great Lakes, Chippewa, Luce Counties, Michigan
Shorelands of the Great Lakes, Mackinac County and Chippewa County East to Brush Pt., MI
Shorelands of the Great Lakes, Schoolcraft, Delta Counties, Michigan
Shorelands of the Great Lakes, Menominee County, Michigan
Shorelands of the Great Lakes, Marinette, Oconto, Brown, Kewaunee, Door Counties, Wisconsin
Shorelands of the Great Lakes, Sheboygan, Manitowoc, Kewaunee Counties, Wisconsin
Shorelands of the Great Lakes, Ozaukee, Milwaukee, Racine, Kenosha Counties, Wisconsin
Shorelands of the Great Lakes, Lake, Cook Counties, Illinois
Shorelands of the Great Lakes, Lake, Porter, La Porte Counties, Indiana
Shorelands of the Great Lakes, Berrien, Van Buren, Allegan, Ottawa Counties, Michigan
Shorelands of the Great Lakes, Benzie, Manistee, Mason, Oceana, Muskegon Counties, Michigan
Shorelands of the Great Lakes, Grand Traverse, Leelanau Counties, Michigan
Shorelands of the Great Lakes, Emmet, Charlevoix, Antrim Counties, Michigan
Shorelands of St. Marys River, Chippewa County, Michigan
Shorelands of the Great Lakes, Alpena, Presque Isle, Cheboygan Counties, Michigan
Shorelands of the Great Lakes, Arenac, Iosco, Alcona Counties, Michigan
Shorelands of the Great Lakes, Tuscola, Bay Counties, Michigan
Shorelands of the Great Lakes, Sanilac, Huron Counties, Michigan
Shorelands of the Great Lakes, Monroe, Wayne, Macomb, St. Clair Counties, Michigan
Shorelands of the Great Lakes, Erie, Sandusky, Ottawa, Lucas Counties, Ohio
Shorelands of the Great Lakes, Ashtabula, Lake, Cuyahoga, Lorain Counties, Ohio
Shorelands of the Great Lakes, Erie County, Pennsylvania
Shorelands of the Great Lakes, Niagara, Erie, Chautauqua Counties, New York
Shorelands of the Great Lakes, Monroe, Orleans Counties, New York
Shorelands of the Great Lakes, Cape Vincent, Jefferson, Oswego, Cayuga, Wayne Counties, NY

TABLE 12–31 Great Lakes Shorelands of Planning Subarea 1.1

	Existing Shoreland		Miles of Shoreline			Problem Identification, Miles of Shoreline				
			Public			Subject to Erosion				
Shoreland Use Category	Miles of Shoreline	Percent of Total	Federal	Non-Federal	Private	Critical	Noncritical	Protected	Subject to Flooding	Not Subject to Erosion or Flooding
Economic Uses										
Residential	99.7	30.1	6.7	0.0	93.0	2.9	18.9	0.0	0.0	77.9
Industrial and commercial	10.2	3.1	0.3	0.0	9.9	5.5	0.7	0.4	0.3	3.3
Agricultural and undeveloped	19.2	5.8	0.0	0.0	19.2	0.6	12.5	0.1	0.0	6.0
Public buildings and related lands	3.9	1.2	1.8	2.1	0.0	1.5	0.8	0.0	0.0	1.6
Recreational Uses										
Parks	27.9	8.4	0.0	27.9	0.0	1.2	7.8	0.0	0.0	18.9
Environmental Uses										
Wildlife preserves and game lands	1.2	0.4	0.0	0.0	1.2	0.0	0.0	0.0	0.0	1.2
Fish and wildlife wetlands (offshore)	---	---	---	---	---	---	---	---	---	---
Forest	169.1	51.1	66.9	4.5	97.7	1.8	64.0	0.0	11.5	91.8
TOTAL	331.2	100.1	75.7	34.5	221.0	13.5	104.7	0.5	11.8	200.7

TABLE 12–32 Great Lakes Shorelands of Planning Subarea 1.2

	Existing Shoreland		Miles of Shoreline			Problem Identification, Miles of Shoreline				
			Public			Subject to Erosion				
Shoreland Use Category	Miles of Shoreline	Percent of Total	Federal	Non-Federal	Private	Critical	Noncritical	Protected	Subject to Flooding	Not Subject to Erosion or Flooding
Economic Uses										
Residential	72.8	12.5	0.0	0.0	72.8	4.5	4.0	2.0	0.0	62.3
Industrial and commercial	9.2	1.6	0.0	0.0	9.2	0.0	0.1	0.9	0.0	8.2
Agricultural and undeveloped	21.2	3.7	0.0	0.0	21.2	0.0	3.0	0.7	0.0	17.5
Public buildings and related lands	5.4	0.9	1.0	4.4	0.0	0.0	0.2	0.0	0.0	5.2
Recreational Uses										
Parks	42.3	7.3	0.0	42.3	0.0	1.3	2.2	0.0	0.0	38.8
Environmental Uses										
Wildlife preserves and game lands	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fish and wildlife wetlands (offshore)	---	---	---	---	---	---	---	---	---	---
Forest	429.9	74.0	14.7	5.8	409.4	9.4	13.7	1.3	0.0	405.5
TOTAL	580.8	100.0	15.7	52.5	512.6	15.2	23.2	4.9	0.0	537.5

TABLE 12–33 Great Lakes Shorelands of Planning Subarea 2.1

	Existing Shoreland		Miles of Shoreline			Problem Identification, Miles of Shoreline				
			Public			Subject to Erosion				
Shoreland Use Category	Miles of Shoreline	Percent of Total	Federal	Non-Federal	Private	Critical	Noncritical	Protected	Subject to Flooding	Not Subject to Erosion or Flooding
Economic Uses										
Residential	130.8	35.8	0.0	0.0	130.8	0.0	49.2	14.6	16.5	50.5
Industrial and commercial	9.5	2.6	0.0	0.0	9.5	0.0	6.6	1.8	1.1	0.0
Agricultural and undeveloped	91.6	25.1	0.0	0.0	91.6	0.0	52.6	0.4	22.5	16.1
Public buildings and related lands	3.5	0.0	0.1	3.4	0.0	0.0	0.1	2.5	0.0	0.9
Recreational Uses										
Parks	40.4	11.0	0.0	39.8	0.6	0.0	22.6	1.1	0.7	16.0
Environmental Uses										
Wildlife preserves and game lands	18.2	5.0	0.0	13.2	5.0	0.0	0.0	0.0	17.2	1.0
Fish and wildlife wetlands (offshore)	(23.1)	(6.3)	---	---	---	---	(5.1)	---	---	---
Forest	71.5	19.6	0.0	0.5	71.0	0.0	18.5	0.0	3.9	49.1
TOTAL	365.5	100.0	0.1	56.9	308.5	0.0	149.6	20.4	61.9	133.6

TABLE 12–34 Great Lakes Shorelands of Planning Subarea 2.2

	Existing Shoreland		Miles of Shoreline			Problem Identification, Miles of Shoreline				
			Public			Subject to Erosion				
Shoreland Use Category	Miles of Shoreline	Percent of Total	Federal	Non-Federal	Private	Critical	Noncritical	Protected	Subject to Flooding	Not Subject to Erosion or Flooding
Economic Uses										
Residential	56.0	29.4	0.0	0.0	56.0	23.1	16.2	16.7	0.0	0.0
Industrial and commercial	38.6	20.3	0.0	0.4	38.2	1.4	0.7	36.5	0.0	0.0
Agricultural and undeveloped	14.4	7.6	0.0	0.0	14.4	4.9	9.5	0.0	0.0	0.0
Public buildings and related lands	14.0	7.3	3.1	10.9	0.0	0.6	2.0	11.4	0.0	0.0
Recreational Uses										
Parks	66.9	35.1	9.3	57.0	0.6	19.5	16.2	31.2	0.0	0.0
Environmental Uses										
Wildlife preserves and game lands	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fish and wildlife wetlands (offshore)	---	---	---	---	---	---	---	---	---	---
Forest	0.6	0.3	0.0	0.0	0.6	0.0	0.6	0.0	0.0	0.0
TOTAL	190.5	100.0	12.4	68.3	109.8	49.5	45.2	95.8	0.0	0.0

TABLE 12–35 Great Lakes Shorelands of Planning Subarea 2.3

	Existing Shoreland		Miles of Shoreline			Problem Identification, Miles of Shoreline				
			Public			Subject to Erosion				
Shoreland Use Category	Miles of Shoreline	Percent of Total	Federal	Non-Federal	Private	Critical	Noncritical	Protected	Subject to Flooding	Not Subject to Erosion or Flooding
Economic Uses										
Residential	75.8	70.3	0.0	0.0	75.8	28.6	46.1	1.1	0.0	0.0
Industrial and commercial	1.2	1.1	0.0	0.0	1.2	0.7	0.5	0.0	0.0	0.0
Agricultural and undeveloped	18.0	16.7	0.0	0.1	17.9	5.5	12.5	0.0	0.0	0.0
Public buildings and related lands	0.1	0.1	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0
Recreational Uses										
Parks	5.0	4.6	0.0	4.6	0.4	0.8	4.2	0.0	0.0	0.0
Environmental Uses										
Wildlife preserves and game lands	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fish and wildlife wetlands (offshore)	---	---	---	---	---	---	---	---	---	---
Forest	7.8	7.2	0.0	0.0	7.8	2.9	4.9	0.0	0.0	0.0
TOTAL	107.9	100.0	0.0	4.8	103.1	38.6	68.2	1.1	0.0	0.0

TABLE 12–36 Great Lakes Shorelands of Planning Subarea 2.4

	Existing Shoreland		Miles of Shoreline			Problem Identification, Miles of Shoreline				
			Public			Subject to Erosion				
Shoreland Use Category	Miles of Shoreline	Percent of Total	Federal	Non-Federal	Private	Critical	Noncritical	Protected	Subject to Flooding	Not Subject to Erosion or Flooding
Economic Uses										
Residential	225.5	28.3	0.0	0.0	225.5	20.9	64.6	14.1	24.1	101.8
Industrial and commercial	24.1	3.0	0.0	0.0	24.1	0.0	2.4	2.3	4.7	14.7
Agricultural and undeveloped	162.0	20.3	0.0	2.3	159.7	6.1	60.8	8.2	7.1	79.8
Public buildings and related lands	3.3	0.4	0.0	3.3	0.0	0.0	0.0	0.0	0.0	3.3
Recreational Uses										
Parks	49.3	6.2	2.0	44.0	3.3	10.9	19.3	1.6	1.0	16.5
Environmental Uses										
Wildlife preserves and game lands	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fish and wildlife wetlands (offshore)	---	---	---	---	---	---	---	---	---	---
Forest	333.9	41.8	20.4	49.2	264.3	4.1	47.3	18.5	44.9	219.1
TOTAL	798.1	100.0	22.4	98.8	676.9	42.0	194.4	44.7	81.8	435.2

TABLE 12-37 Great Lakes Shorelands of Planning Subarea 3.1

	Existing Shoreland		Miles of Shoreline			Problem Identification, Miles of Shoreline				
			Public			Subject to Erosion				
Shoreland Use Category	Miles of Shoreline	Percent of Total	Federal	Non-Federal	Private	Critical	Noncritical	Protected	Subject to Flooding	Not Subject to Erosion or Flooding
Economic Uses										
Residential	105.0	39.9	0.0	0.0	105.0	6.6	36.8	0.0	2.2	59.4
Industrial and commercial	9.7	3.7	0.0	0.0	9.7	0.0	2.7	0.0	0.0	7.0
Agricultural and undeveloped	29.0	11.0	0.0	0.0	29.0	1.2	18.6	0.0	1.5	7.7
Public buildings and related lands	2.2	0.8	0.0	2.2	0.0	0.0	0.5	0.0	0.0	1.7
Recreational Uses										
Parks	18.9	7.2	0.0	18.9	0.0	0.0	0.0	0.0	0.0	18.9
Environmental Uses										
Wildlife preserves and game lands	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fish and wildlife wetlands (offshore)	---	---	---	---	---	---	---	---	---	---
Forest	98.5	37.4	0.0	3.2	95.3	0.0	4.3	0.0	3.5	90.7
TOTAL	263.3	100.0	0.0	24.3	239.0	7.8	62.9	0.0	7.2	185.4

TABLE 12-38 Great Lakes Shorelands of Planning Subarea 3.2

	Existing Shoreland		Miles of Shoreline			Problem Identification, Miles of Shoreline				
			Public			Subject to Erosion				
Shoreland Use Category	Miles of Shoreline	Percent of Total	Federal	Non-Federal	Private	Critical	Noncritical	Protected	Subject to Flooding	Not Subject to Erosion or Flooding
Economic Uses										
Residential	94.2	49.8	0.0	0.0	94.2	0.0	72.1	0.0	14.6	7.5
Industrial and commercial	4.1	2.2	0.0	0.0	4.1	0.0	1.2	0.0	2.9	0.0
Agricultural and undeveloped	49.9	26.4	0.0	0.0	49.9	0.0	10.7	0.0	37.0	2.2
Public buildings and related lands	0.2	0.1	0.0	0.2	0.0	0.0	0.1	0.0	0.0	0.1
Recreational Uses										
Parks	4.9	2.6	0.0	4.9	0.0	0.2	2.8	0.0	0.0	1.9
Environmental Uses										
Wildlife preserves and game lands	17.1	9.0	0.0	17.1	0.0	0.0	0.0	0.0	1.5	15.6
Fish and wildlife wetlands (offshore)	---	---	---	---	---	---	---	---	---	---
Forest	18.7	9.9	0.0	0.0	18.7	0.0	4.6	0.0	8.7	5.4
TOTAL	189.1	100.0	0.0	22.2	166.9	0.2	91.5	0.0	64.7	32.7

TABLE 12-39 Great Lakes Shorelands of Planning Subarea 4.1

	Existing Shoreland		Miles of Shoreline			Problem Identification, Miles of Shoreline				
			Public			Subject to Erosion				
Shoreland Use Catagory	Miles of Shoreline	Percent of Total	Federal	Non-Federal	Private	Critical	Noncritical	Protected	Subject to Flooding	Not Subject to Erosion or Flooding
Economic Uses										
Residential	62.3	67.6	0.0	0.0	62.3	0.0	0.0	21.3	29.8	11.2
Industrial and commercial	2.7	2.9	0.0	0.0	2.7	0.0	0.0	0.9	1.8	0.0
Agricultural and undeveloped	8.7	9.5	0.0	0.0	8.7	0.0	0.0	1.8	6.5	0.4
Public buildings and related lands	2.3	2.5	0.0	2.3	0.0	0.0	0.0	2.3	0.0	0.0
Recreational Uses										
Parks	5.9	6.4	0.0	5.9	0.0	0.0	0.0	2.1	2.8	1.0
Environmental Uses										
Wildlife preserves and game lands	10.2	11.1	0.0	10.2	0.0	0.0	0.0	0.0	10.2	0.0
Fish and wildlife wetlands (offshore)	---	---	---	---	---	---	---	---	---	---
Forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	92.1	100.0	0.0	18.4	73.7	0.0	0.0	28.4	51.1	12.6

TABLE 12-40 Great Lakes Shorelands of Planning Subarea 4.2

	Existing Shoreland		Miles of Shoreline			Problem Identification, Miles of Shoreline				
			Public			Subject to Erosion				
Shoreland Use Category	Miles of Shoreline	Percent of Total	Federal	Non-Federal	Private	Critical	Noncritical	Protected	Subject to Flooding	Not Subject to Erosion or Flooding
Economic Uses										
Residential	37.1	45.0	0.0	0.0	37.1	0.0	8.3	25.6	0.2	3.0
Industrial and commercial	4.9	5.9	0.0	0.0	4.9	0.0	0.0	4.3	0.0	0.6
Agricultural and undeveloped	11.9	14.4	0.0	0.0	11.9	0.0	7.7	0.5	2.6	1.1
Public buildings and related lands	4.3	5.2	1.1	3.2	0.0	0.0	1.9	2.4	0.0	0.0
Recreational Uses										
Parks	10.6	12.9	0.1	6.9	3.6	0.0	3.4	3.6	1.6	2.0
Environmental Uses										
Wildlife preserves and game lands	10.8	13.1	5.6	5.2	0.0	0.0	3.1	1.6	6.1	0.0
Fish and wildlife wetlands (offshore)	(NA)	(NA)	---	---	---	---	---	---	---	---
Forest	2.9	3.5	0.0	0.0	2.9	0.0	1.6	0.4	0.3	0.6
TOTAL	82.5	100.0	6.8	15.3	60.4	0.0	26.0	38.4	10.8	7.3

TABLE 12-41 Great Lakes Shorelands of Planning Subarea 4.3

	Existing Shoreland		Miles of Shoreline			Problem Identification, Miles of Shoreline				
			Public			Subject to Erosion				
Shoreland Use Category	Miles of Shoreline	Percent of Total	Federal	Non-Federal	Private	Critical	Noncritical	Protected	Subject to Flooding	Not Subject to Erosion or Flooding
Economic Uses										
Residential	59.3	55.0	0.0	0.0	59.3	11.1	1.5	46.6	0.0	0.1
Industrial and commercial	10.1	9.4	0.0	0.0	10.1	0.7	0.0	4.5	0.0	4.9
Agricultural and undeveloped	14.2	13.2	0.0	0.0	14.2	0.3	9.1	4.4	0.0	0.4
Public buildings and related lands	7.6	7.0	0.0	7.6	0.0	0.5	0.0	1.7	0.0	5.4
Recreational Uses										
Parks	15.1	14.0	0.0	11.3	3.8	1.7	0.5	9.3	0.0	3.6
Environmental Uses										
Wildlife preserves and game lands	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fish and wildlife wetlands (offshore)	---	---	---	---	---	---	---	---	---	---
Forest	1.5	1.4	0.0	1.5	0.0	0.0	0.8	0.7	0.0	0.0
TOTAL	107.8	100.0	0.0	20.4	87.4	14.3	11.9	67.2	0.0	14.4

TABLE 12-42 Great Lakes Shorelands of Planning Subarea 4.4

	Existing Shoreland		Miles of Shoreline			Problem Identification, Miles of Shoreline				
			Public			Subject to Erosion				
Shoreland Use Category	Miles of Shoreline	Percent of Total	Federal	Non-Federal	Private	Critical	Noncritical	Protected	Subject to Flooding	Not Subject to Erosion or Flooding
Economic Uses										
Residential	62.1	41.3	0.0	0.0	62.1	1.5	31.7	9.0	0.3	19.6
Industrial and commercial	12.8	8.5	0.0	0.0	12.8	0.0	3.6	6.5	0.3	2.4
Agricultural and undeveloped	45.0	29.9	0.0	0.0	45.0	0.3	21.3	0.0	0.1	23.3
Public buildings and related lands	4.9	3.3	0.0	4.9	0.0	0.0	0.0	3.4	0.0	1.5
Recreational Uses										
Parks	25.6	17.0	0.0	25.6	0.0	9.1	11.1	5.4	0.0	0.0
Environmental Uses										
Wildlife preserves and game lands	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fish and wildlife wetlands (offshore)	---	---	---	---	---	---	---	---	---	---
Forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	150.4	100.0	0.0	30.5	119.9	10.9	67.7	24.3	0.7	46.8

TABLE 12–43 Great Lakes Shorelands of Planning Subarea 5.1

Shoreland Use Category	Existing Shoreland: Miles of Shoreline	Existing Shoreland: Percent of Total	Miles of Shoreline: Public: Federal	Miles of Shoreline: Public: Non-Federal	Miles of Shoreline: Private	Problem Identification, Miles of Shoreline: Subject to Erosion: Critical	Subject to Erosion: Noncritical	Protected	Subject to Flooding	Not Subject to Erosion or Flooding
Economic Uses										
Residential	35.2	59.6	0.0	0.0	35.2	0.0	18.4	6.9	9.9	0.0
Industrial and commercial	3.1	5.3	0.0	0.0	3.1	0.4	0.0	2.7	0.0	0.0
Agricultural and undeveloped	11.3	19.1	0.0	0.0	11.3	0.3	10.0	0.0	1.0	0.0
Public buildings and related lands	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Recreational Uses										
Parks	9.5	16.0	0.0	9.5	0.0	6.7	0.2	2.6	0.0	0.0
Environmental Uses										
Wildlife preserves and game lands	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fish and wildlife wetlands (offshore)	---	---	---	---	---	---	---	---	---	---
Forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	59.1	100.0	0.0	9.5	49.6	7.4	28.6	12.2	10.9	0.0

TABLE 12–44 Great Lakes Shorelands of Planning Subarea 5.2

Shoreland Use Category	Existing Shoreland: Miles of Shoreline	Existing Shoreland: Percent of Total	Miles of Shoreline: Public: Federal	Miles of Shoreline: Public: Non-Federal	Miles of Shoreline: Private	Problem Identification, Miles of Shoreline: Subject to Erosion: Critical	Subject to Erosion: Noncritical	Protected	Subject to Flooding	Not Subject to Erosion or Flooding
Economic Uses										
Residential	25.8	32.7	0.0	0.0	25.8	0.0	22.1	3.4	0.0	0.3
Industrial and commercial	5.9	7.5	0.0	0.0	5.9	0.0	5.5	0.0	0.0	0.4
Agricultural and undeveloped	35.8	45.3	0.0	0.0	35.8	0.0	35.2	0.0	0.0	0.6
Public buildings and related lands	1.7	2.2	0.0	1.7	0.0	0.0	1.4	0.0	0.0	0.3
Recreational Uses										
Parks	9.7	12.3	0.0	9.7	0.0	4.5	4.9	0.3	0.0	0.0
Environmental Uses										
Wildlife preserves and game lands	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fish and wildlife wetlands (offshore)	---	---	---	---	---	---	---	---	---	---
Forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	78.9	100.0	0.0	11.4	67.5	4.5	69.1	3.7	0.0	1.6

TABLE 12–45 Great Lakes Shorelands of Planning Subarea 5.3

Shoreland Use Category	Existing Shoreland: Miles of Shoreline	Existing Shoreland: Percent of Total	Miles of Shoreline: Public: Federal	Miles of Shoreline: Public: Non-Federal	Miles of Shoreline: Private	Problem Identification, Miles of Shoreline: Subject to Erosion: Critical	Subject to Erosion: Noncritical	Protected	Subject to Flooding	Not Subject to Erosion or Flooding
Economic Uses										
Residential	49.8	41.4	0.0	0.0	49.8	0.0	21.1	3.4	0.0	25.3
Industrial and commercial	11.6	9.6	0.0	0.0	11.6	0.0	6.8	1.1	0.0	3.7
Agricultural and undeveloped	54.1	44.9	0.0	0.0	54.1	0.0	21.1	0.0	7.5	25.5
Public buildings and related lands	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Recreational Uses										
Parks	4.9	4.1	0.0	4.9	0.0	0.0	1.2	0.0	0.0	3.7
Environmental Uses										
Wildlife preserves and game lands	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fish and wildlife wetlands (offshore)	---	---	---	---	---	---	---	---	---	---
Forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	120.4	100.0	0.0	4.9	115.5	0.0	50.2	4.5	7.5	58.2

TABLE 12–46 Critical Bird Nesting and Migration Areas

Area	Map Location	Nesting Areas	Migration Areas	Remarks
COOK COUNTY, MINNESOTA				
Pigeon Point	1	Herring Gull	---	
Lucille Island	2	Herring Gull, Blue Heron	---	
Pancake Island	3	Herring Gull	---	
Gull Island	4	Herring Gull	---	
CARLTON, ST. LOUIS, & LAKE COUNTIES, MINNESOTA				
Encampment Island	1	Herring Gull	---	Large colony. Private owner (planning summer house) has been crushing eggs.
Knife Island	2	Herring Gull	---	
Duluth Bluffs	3	---	Hawk	
J. Cook Park	3	---	---	
Lester Park	3	---	---	Spring and fall bird of prey major concentration point.
St. Louis River Bottomlands	4	---	Hawk	Migrating eagles feeding-resting point.
Spoil Island	5	Common Tern	---	Threatened by dune buggies and motorcycle activities. Duluth Port Authority and Corps of Engineers.
Minnesota Point	6	Herring Gull Common Tern	Shorebird, Passerine, Hawk	Kestrels & Merlins roost here on migration.
IRON, ASHLAND, BAYFIELD, & DOUGLAS COUNTIES, WISCONSIN				
Allouez Bay	1	---	Waterfowl	Major diving duck concentrations.
Mouth of Brule	2	---	Waterfowl, Shorebird, Passerine	
Port Wing Slough	3	Waterfowl	Waterfowl, Shorebird, Passerine	Nesting and migration importance.
Bark Bay Slough & Point	4	Waterfowl	Waterfowl, Shorebird, Passerine	Major nesting and resting.
Eagle Island	5	Herring Gull	---	
Sand Point	6	---	Waterfowl, Shorebird, Passerine, Hawk	
Point Detour	7	---	Waterfowl, Shorebird, Passerine, Hawk	
Devils Island	8	Herring Gull	---	
Outer Island Slough	9	Waterfowl	Waterfowl, Passerine	
Raspberry Bay (Mouth of River)	10	---	---	Waterfowl wintering and nesting.
Red Cliff Bay	11	---	---	Waterfowl wintering and resting.
Eastern Hermit Island	12	Herring Gull	---	
South Stockton Island	13	Waterfowl	Waterfowl, Passerine	
Stockton Island Slough	14	Waterfowl	Waterfowl, Passerine	
Michigan Island Slough (southwest portion)	15	Waterfowl	Waterfowl, Passerine	
Gull Island (off Michigan Island)	16	Herring Gull	---	
Mouth of Pikes Creek	17	---	---	Waterfowl wintering and resting spot.
Big Bay Shore (Madeline Island)	18	Blue Heron	---	
Kakagon Sloughs & Oak Point	19	Waterfowl	Waterfowl, Shorebird, Woodcock, Passerine, Hawk	One of finest marsh habitats along Lake Superior shore.
Mouth of Fish Creek	20	---	---	Duck and swan resting place for migration.
ONTONAGON & GOGEBIC COUNTIES, MICHIGAN	--	---	---	
BARAGA, HOUGHTON, & KEWEENAW COUNTIES, MICHIGAN				
Lake Bailey Marshes	1	Waterfowl	Waterfowl	
Lake Upson Marshes	2	Waterfowl	Waterfowl	
Copper Harbor Island	3	Herring Gull	---	
Keweenaw Point & Copper Harbor	4	---	Passerine, Hawk	
Isle Royale	5	Herring Gull	Osprey	Tourists noted several colonies on outlying rocks.
Traverse Island	6	Blue Heron	---	
Sand Point Marsh	7	Waterfowl	Waterfowl, Shorebird, Passerine	
Point Abbaye	8	---	Passerine, Hawk	
MARQUETTE & ALGER COUNTIES, MICHIGAN				
Huron Islands	1	Herring Gull, Blue Heron	---	Last known Peregrine nesting site in Upper Peninsula.
Larus Island	2	Herring Gull	---	
Partridge Island	3	Eagle	---	
Middle Island (near Marquette)	4	Herring Gull	---	

TABLE 12–46(continued) Critical Bird Nesting and Migration Areas

Area	Map Location	Nesting Areas	Migration Areas	Remarks
MARQUETTE & ALGER COUNTIES, MICHIGAN (continued)				
White Rocks (near Presque Isle)	5	Herring Gull	---	
Presque Isle Park Breakwater	6	---	---	Shorebird nesting.
Mouth of Dead River	7	---	Waterfowl	
Mouth of Chocolay River	8	Blue Heron	---	
Williams Island	9	Herring Gull	---	
Pictured Rocks	10	Herring Gull	---	
Grand Marais Island	11	Herring Gull	---	
CHIPPEWA & LUCE COUNTIES, MICHIGAN				
Whitefish Point	1	---	Waterfowl, Shorebird, Passerine, Hawk	A migration focal point of prime importance.
Round Island	2	Herring Gull, Ring billed Gull	---	
MACKINAC & CHIPPEWA COUNTIES, MICHIGAN (East to Brush Point)				
Naubinway Island	1	Herring Gull Ring billed Gull	---	
Little Hog Island	2	Herring Gull	---	
St. Helena Island	3	Blue Heron	---	
Green Island	4	Herring Gull, Ring billed Gull, Common Tern	---	
St. Martins Shoal	5	Herring Gull, Ring billed Gull	Shorebird	Major Herring Gull colony & migratory route shorebirds.
St. Martins Reef	6	Ring billed Gull, Common Tern	---	
Goose Island	7	Ring billed Gull, Common Tern	---	No birds noted in 1962.
Packard Point Island	8	Ring billed Gull	---	
Beaver Tail Point Island	9	Herring Gull	---	
Beaver Tail Reef Island	10	Common Tern	---	
SCHOOLCRAFT & DELTA COUNTIES, MICHIGAN				
Bay De Noc	1	---	Woodcock	Major shorebird migration area.
Snake Island	2	Herring Gull	---	
Little Summer Island	3	Herring Gull, Ring billed Gull, Common Tern	---	
W. of Little Summer Island	4	Ring billed Gull	---	
Gravelly Island	5	Herring Gull, Caspian Tern	---	Major Caspian Tern colony and major shorebird stopover.
MENOMINEE COUNTY, MICHIGAN				
Green Island	1	Herring Gull	---	
Peshtigo Point & River	2	Black Tern, Waterfowl	Passerine	
MARINETTE, OCONTO, BROWN, KEWAUNEE, & DOOR COUNTIES, WISCONSIN				
Oconto River Mouth	1	Black Tern, Waterfowl	Passerine	
Little Tail Point	2	---	Passerine	
Long Tail Point	3	---	Passerine	
Sable Point	4	---	Passerine	
Hatt Island in Egg Harbor	5	Herring Gull	---	
Jack Island in Strawberry Island Group	6	Herring Gull, Waterfowl	---	
Sister Islands (2)	7	Herring Gull	---	
Rock Island	8	Herring Gull	---	
Hog Island (East of Washington Island)	9	Herring Gull	---	
Gravel Island	10	Herring Gull	---	
Spider Island	11	Herring Gull, Blue & Night Herons	---	
North Bay	12	Black Tern	---	
Moonlight Bay	13	Black Tern, Waterfowl	Passerine	
Ridges Santuary (at Baileys Harbor Point)	14	Waterfowl	Waterfowl, Shorebird, Passerine	Owned by University of Wisconsin
SHEBOYGAN, MANITOWOC & KEWAUNEE COUNTIES, WISCONSIN				
Cedar Grove Ornithological Station	1	---	Passerine, Hawk	Connected with University of Wisconsin.

TABLE 12-46(continued) Critical Bird Nesting and Migration Areas

Area	Map Location	Nesting Areas	Migration Areas	Remarks
OZAUKEE, MILWAUKEE, RACINE, & KENOSHA COUNTIES, WISCONSIN		None	---	
LAKE & COOK COUNTIES, ILLINOIS				
Zion Beach	1	---	Hawk	
LAKE, PORTER, & LA PORTE COUNTIES, INDIANA		None	---	
BERRIEN, VAN BUREN, ALLEGAN, & OTTAWA COUNTIES, MICHIGAN				
Grand Beach to Warren Dunes State Park	1	---	---	Major staging areas for diving ducks, loons, grebes, and other waterfowl.
New Buffalo Harbor	2	---	Waterfowl, Shorebird	Many Oldsquaw & other diving ducks winter here.
Warren Dunes State Park	3	---	Passerine	Rare Prairie Warbler found nesting on shrubby beach areas.
Junction of St. Joseph River & Paw Paw to Mouth	4	---	Waterfowl, Shorebird, Woodcock, Passerine, Hawk	Daytime migration at foot of Higmans Hill, some days 40,000.
Kalamazoo Lake & Saugatuck Marsh	5	Black Tern, Waterfowl	Waterfowl, Shorebird, Passerine	
Windmill Park Marsh (Holland)	6	Black Tern, Blue Heron	---	Important marsh nesting habitat. Many migrating species pass through this area.
Port Sheldon Harbor & Pigeon Lake	7	---	Waterfowl	Mainly overwintering diving ducks, but unusual sea and ocean ducks often seen.
Grand Haven Marsh	8	Black Tern, Waterfowl	Waterfowl, Shorebird, Passerine, Hawk	Municipal dumping & filling endangering important marsh habitat. King, Virginia, & Sora Rail & first Yellow-Headed Blackbirds nest here.
BENZIE, MANISTEE, MASON, OCEANA, & MUSKEGON COUNTIES, MICHIGAN	1	---		
Muskegon River Mouth & Muskegon State Park	1	Black Tern, Waterfowl	Waterfowl, Shorebird, Passerine, Hawk	A major sanctuary area, being partly endangered by fly-ash filling by Consumers Power Co. Large hawk migrations.
Big Sable Point & Ludington State Park	2	---	Shorebird, Passerine, Hawk	
Hamlin Lake	3	---	Waterfowl	Captive geese flocks & large geese migration.
Elberta Marsh	4	Waterfowl	Shorebird, Passerine, Hawk	Canada Geese.
Point Betsie	5	---	Shorebird, Passerine, Hawk	
Benzie State Park	6	---	Shorebird, Passerine, Hawk	
GRAND TRAVERSE & LEELANAU COUNTIES, MICHIGAN				
Sleeping Bear Point	1	---	Shorebird, Woodcock, Passerine, Hawk	
Sandy Point (South Manitou Island)	2	Herring Gull, Ring billed Gull	Shorebird, Passerine	Large passerine migrations.
Gull Point (South Manitou Island)	3	Herring Gull, Ring billed Gull	---	Southernmost gull colony & one of largest in lower Michigan.
Lighthouse Point & Cathead Bay	4	Common Tern	Waterfowl, Shorebird, Woodcock, Passerine, Hawk	Shoals in low water years.
Bellows Island	5	Herring Gull	---	
Greilickville	6	---	Waterfowl	Mute Swans feed here.
Old Mission Point Shoals	7	Herring Gull, Ring billed Gull, Common Tern	---	Mute Swans nesting. Submerged in high water years.
Ptobego Marsh	8	Black Tern, Waterfowl	Waterfowl, Shorebird, Passerine	
EMMET, CHARLEVOIX, & ANTRIM COUNTIES, MICHIGAN				
Elk River Mouth	1	---	---	Swans nesting.
Harbor Springs	2	---	Passerine	
Isle Galet	3	Herring Gull, Ring billed Gull, Common & Caspian Tern	---	
Waugoshance Island	4	Herring Gull, Common Tern	---	
Waugoshance Point	5	Herring Gull, Ring billed Gull	Shorebird	
Cecil Bay Island	6	Common Tern	---	
Shoreline West of Mackinaw City	7	---	Shorebird, Passerine	One of major spring concentration points for many species. Funnel for whole lower peninsula of Michigan.
Straits of Mackinac	8	---	Hawk	
Shoe Island	9	Herring Gull, Common & Caspian Tern	---	Bad erosion.

TABLE 12–46(continued) Critical Bird Nesting and Migration Areas

Area	Map Location	Nesting Areas	Migration Areas	Remarks
EMMET, CHARLEVOIX, & ANTRIM COUNTIES, MICHIGAN (continued)				
Hat Island	10	Herring Gull, Caspian Tern, Black Crown Night Heron	---	
Hog Island	11	---	Woodcock	
Grape Island	12	Ring billed Gull	---	
Garden Island	13	---	Woodcock	
Pismire Island	14	Blue Heron, Black Crown Night Heron	---	
Reef East of Pismire	15	Ring billed Gull	---	
Grass Island Reef	16	Ring billed Gull	---	
Grass Island	17	Herring Gull, Ring billed Gull, Common Tern	---	
High Island Shoals	18	Common Tern	---	
High Island	19	Herring Gull, Ring billed Gull, Caspian Tern	Woodcock	
Big Gull Island	20	Herring Gull, Ring billed Gull	---	
ST. MARYS RIVER CHIPPEWA COUNTY, MICHIGAN				
N.E. of Neebish Island	1	Ring billed Gull	---	
S.E. of Neebish Island	2	Ring billed Gull	---	
S.W. of Neebish Island	3	Ring billed Gull	---	
Squaw Island	4	Herring Gull	---	
Moon Island	5	Ring billed Gull	---	
Andrews Island	6	Ring billed Gull	---	
Rocks W. Long Island	7	Herring Gull	---	
Burnt Island	8	Blue Heron	---	
Harbor Island Reef	9	Herring Gull, Ring billed Gull, Common Tern	---	
Gull Island	10	Herring Gull, Ring billed Gull, Common Tern, Blue, Black Crown Night & Green Herons	---	
Propeller Island	11	Herring Gull	---	
Pipe Island Twins	12	Herring Gull	---	
Frying Pan Island	13	Common Tern	---	
Gravel Island (off Drummond Island)	14	Herring Gull, Common Tern	---	
Espanore Island	15	Blue Heron	---	
Detour Shoal	16	Common Tern	---	
Reef in St. Vital Bay	17	Common Tern	---	
ALPENA, PRESQUE ISLE, & CHEBOYGAN COUNTIES, MICHIGAN				
Calcite	1	Herring Gull, Ring billed Gull, Common Tern	Shorebird	
Calcite Flats	2	---	Shorebird	
False Presque Isle	3	---	Passerine, Hawk	
North Point	4	---	Passerine, Hawk	
Gull Island	5	Herring Gull, Ring billed Gull, Common Tern, Blue, Night & Green Heron	Shorebird	Canada Geese
Thunder Bay Island	6	Herring Gull, Ring billed Gull, Common Tern	Shorebird	
Sugar Island	7	Herring Gull, Ring billed Gull, Night Heron	Shorebird	Canada Geese
Whitefish Bay	8	Waterfowl	---	Waterfowl wintering spot.
Grass Island	9	Herring Gull, Ring billed Gull, Common Tern, Black Crown & Green Heron	Waterfowl, Shorebird	
Squaw Bay	10	Waterfowl	---	
Sulphur Island	11	Ring billed Gull, Black Crown & Green Heron	Shorebird	Hawk nests. Only in high water years.
Scarecrow Island	12	Herring Gull, Ring billed Gull, Common & Black Tern, Blue & Black Crown Heron	Shorebird	Canada Geese

TABLE 12–46(continued) Critical Bird Nesting and Migration Areas

Area	Map Location	Nesting Areas	Migration Areas	Remarks
ALPENA, PRESQUE ISLE, & CHEBOYGAN COUNTIES, MICHIGAN (continued)				
Bird Island	13	Herring Gull, Ring billed Gull, Black Crown & Green Heron	Shorebird	
South Point	14	---	Passerine, Hawk	Exceptional concentration of nocturnal and diurnal passerines.
ARENAC, IOSCO, & ALCONA COUNTIES, MICHIGAN				
Black River Island Shoals	1	Herring Gull, Ring billed Gull, Common Tern	Shorebird	
Reef South Black River	2	Ring billed Gull, Common Tern	---	
Au Sable Point	3	---	Waterfowl, Shorebird, Woodcock, Passerine, Hawk	Mainly shorebird migration.
Tawas Point	4	---	Waterfowl, Shorebird, Woodcock, Passerine, Hawk	Prime focal point for migration. Two banders average 3,000 per week.
Point Lookout	5	---	Waterfowl, Shorebird, Woodcock, Passerine, Hawk	
Point Au Gres	6	---	Waterfowl, Shorebird, Woodcock, Passerine, Hawk	
TUSCOLA & BAY COUNTIES, MICHIGAN				
Ptobico Marsh	1	Black Tern, Waterfowl	Waterfowl, Shorebird, Woodcock, Passerine, Hawk	
Spoils Island	2	Ring billed Gull, Common Tern, Waterfowl	---	Army Corps is dredging.
Fish Point	3	---	Waterfowl, Shorebird, Woodcock, Passerine, Hawk	
SANILAC & HURON COUNTIES, MICHIGAN				
Lone Tree Island	1	Common Tern	---	
Katechay Island Bay	2	Waterfowl	Waterfowl	
Wildfowl Bay	3	---	Waterfowl	
Sand Point	4	---	Waterfowl, Shorebird, Woodcock, Passerine, Hawk	
Duck Island	5	Common Tern	---	
Little Charity Island	6	Ring billed Gull, Common & Caspian Tern, Black Crown Night Heron	Shorebird	Use this map for location of numbered areas. Large color map following is unnumbered.
Charity Island Reef	7	Ring billed Gull, Common & Caspian Tern	Shorebird	
Rush Lake (near Sleeper State Park)	8	Black Crown Night Heron	---	
Port Austin Reef	9	Ring billed Gull	---	Periodically under water.
MONROE, WAYNE, MACOMB, & ST. CLAIR COUNTIES, MICHIGAN				
St. Clair River	1	---	---	Important for wintering diving ducks
Metropolitan Beach	2	Common Tern	---	
Dickinson Island	3	Common Tern	---	
Belle Isle	4	Common Tern	---	
Spoils Island (North of Grassy Island)	5	Common Tern	---	
Stoney Island	6	Blue & Black Crown Night Heron	---	Egrets also have nested here.
Dickinsons & Harsens Island	7	Waterfowl	Waterfowl	Important marsh habitat.
Lower Detroit River (areas marked)	8	---	Waterfowl	Essential for wintering waterfowl, particularly diving ducks.
Marsh in Pointe Mouillee State Game Refuge	9	Common Tern Black Tern Waterfowl	Waterfowl, Shorebird, Passerine, Hawk	
Pointe Mouillee	10	Common Tern, Black Tern, Waterfowl,	Waterfowl, Shorebird, Passerine, Hawk	Particularly important for migrating hawks.
Sterling State Park	11	Common Tern, Black Tern, Waterfowl	Waterfowl, Shorebird, Passerine, Hawk	

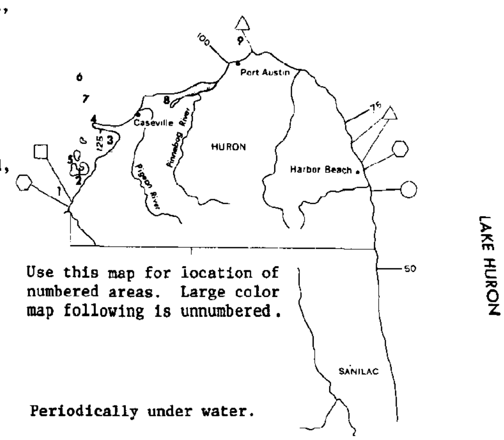
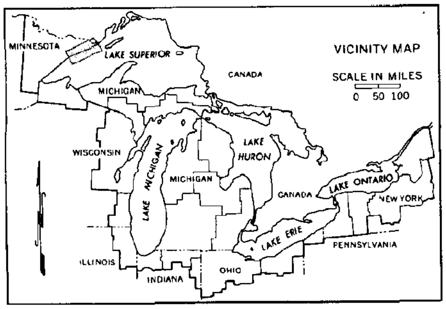


TABLE 12-46(continued) Critical Bird Nesting and Migration Areas

Area	Map Location	Nesting Areas	Migration Areas	Remarks
MONROE, WAYNE, MACOMB, & ST. CLAIR COUNTIES, MICHIGAN (continued)				
Mouth of Raisin River	12	Common Tern, Black Tern, Waterfowl	Waterfowl, Shorebird, Passerine, Hawk	Only place near Great Lakes where Yellow Crown Night Heron are known to nest.
Bolles Harbor	13	Common Tern, Black Tern, Waterfowl	Waterfowl, Shorebird, Passerine, Hawk	
Wood Tick Peninsula (including North Cape)	14	Common Tern, Black Tern, Waterfowl	Waterfowl, Shorebird, Passerine, Hawk	Atlantic & Mississippi migration flyways cross here at west end of Lake Erie. All these areas of major importance Erie Marsh area.
ERIE, SANDUSKY, OTTAWA, & LUCAS COUNTIES, OHIO				
Ottawa National Wildlife Refuge	1	Eagle	---	Pintail and Metzger Marsh.
Cedar Point	2	Eagle	---	Damaged by resort development.
Magee Marsh State Park	3	Eagle	Waterfowl, Shorebird, Passerine, Hawk	
West Sisters Islands	4	Blue & Green Heron	---	100 Egrets nesting.
Darby Marsh	5	Black Tern, Waterfowl	Waterfowl, Shorebird, Woodcock, Passerine, Hawk	
Port Clinton Marsh	6	---	Shorebird	Wading bird resting spot. Egrets feed here. In danger of filling by village authorities.
Ottawa Marsh	7	Eagle	Waterfowl, Shorebird, Passerine, Woodcock, Hawk	
Winisk Point	8	Eagle	Waterfowl, Shorebird, Woodcock, Passerine, Hawk	
East Harbor	9	---	Waterfowl	
West Harbor	9	---	---	
Middle Harbor (on Catawba Island)	9	---	---	Resting area for migrating waterfowl.
Starve Island	10	Herring Gull	---	
Green Island	11	Eagle	Passerine	
South Bass Island	12	---	Passerine	Cedar roost west of Put-in-Bay, owned by Hineman Winery, is major stopover for blackbirds.
North Bass Island Marsh	13	Night Heron, Waterfowl	Waterfowl, Shorebird	Major blackbird, Robin, & Bluejay flights stopover here from Point Pelee.
Ballast Island	14	Herring Gull, Ring billed Gull	---	
Gull Island Shoal	15	Herring Gull	---	
Kelleys Island Marsh	16	Waterfowl	Waterfowl, Passerine	Nearly filled in.
Cedar Point	17	Eagle	Waterfowl, Shorebird, Woodcock, Passerine, Hawk	
ASHTABULA, LAKE, CUYAHOGA, & LORAIN COUNTIES, OHIO				
Perkins Beach	1	---	Hawk	
Edgewater Park	2	---	Hawk	
Walnut Beach	3	---	Shorebird, Hawk	
ERIE COUNTY, PENNSYLVANIA				
Presque Isle	1	Eagle	Waterfowl, Shorebird, Passerine, Hawk	Finest large marsh on Lake Erie shore. Great migrations used by Edinburgh College for research. A fragile sand-spit habitat.
NIAGARA, ERIE, & CHAUTAUQUA COUNTIES, NEW YORK				
Chautauqua Gorge	1	Eagle	Passerine	
Canadican Creek	2	---	Passerine	One of last undeveloped wild stream valleys on Lake Erie shore.
Dunkirk Park	3	---	Passerine, Hawk	Small but important migrant staging and resting area.
Kift Farm	4	Black Tern	Waterfowl, Shorebird, Woodcock, Passerine, Hawk	
Strawberry Island	5	Black Tern, Waterfowl	Waterfowl, Shorebird, Woodcock, Passerine, Hawk	
Buckhorn Island	6	Herring Gull, Ring billed Gull	Waterfowl, Passerine, Hawk	

TABLE 12–46(continued) Critical Bird Nesting and Migration Areas

Area	Map Location	Nesting Areas	Migration Areas	Remarks
MONROE & ORLEANS COUNTIES, NEW YORK				
Johnson Creek	1	Black Tern, Waterfowl	---	
Oak Orchard Creek	2	Black Tern, Waterfowl	---	
Braddock Bay	3	Black Tern	Passerine, Hawk	
CAPE VINCENT, JEFFERSON, OSWEGO, CAYUGA, & WAYNE COUNTIES, NEW YORK				
Sodus Bay	1	---	Waterfowl, Shorebird, Passerine, Hawk	Major migration focal point. Point of departure for southward migration, following areas are similar: Sodus Point, particularly for hawk migration and diurnal passerines.
East Bay	2	---	Waterfowl, Shorebird, Passerine, Hawk	
Little Sodus Bay	3	---	Waterfowl, Shorebird, Passerine, Hawk	
Mouth of Oswego River	4	---	Waterfowl	Up to 10,000 waterfowl winter here.
Derby Hill	5	---	Hawk	Nature conservancy.
Selkirk Shores State Park	6	---	Passerine, Hawk	Great numbers of swallows and other diurnal passerines.
Eldorado Shores	7	Waterfowl	Waterfowl, Shorebird	30 species shorebirds. 20 to 25 species waterfowl. Nature conservancy owned.
Lakeview Wildlife Management Area	8	---	Waterfowl, Hawk	State owned. Major waterfowl migration, spectacular brant flights come south in Fall; major hawk migration; important goose concentration area. Sandy pond bordered by sand spit not in public ownership. Migrating warblers, shorebirds, and hawks.
Henderson Bay	9	---	Waterfowl	
Little Galloo Island	10	Ring billed Gull	---	Largest gull colony in Great Lakes.
Gull Island	11	Black Crown Night Heron	---	Cormorants nest here also.
Bass Island	12	Black Crown Night Heron	---	Cormorants nest here also.
Pillar Point	13	---	Hawk	
Chaumont Bay	14	---	Waterfowl, Shorebird	
Three Mile Bay	15	---	Shorebird	Large diving duck concentration in winter.



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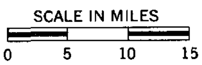
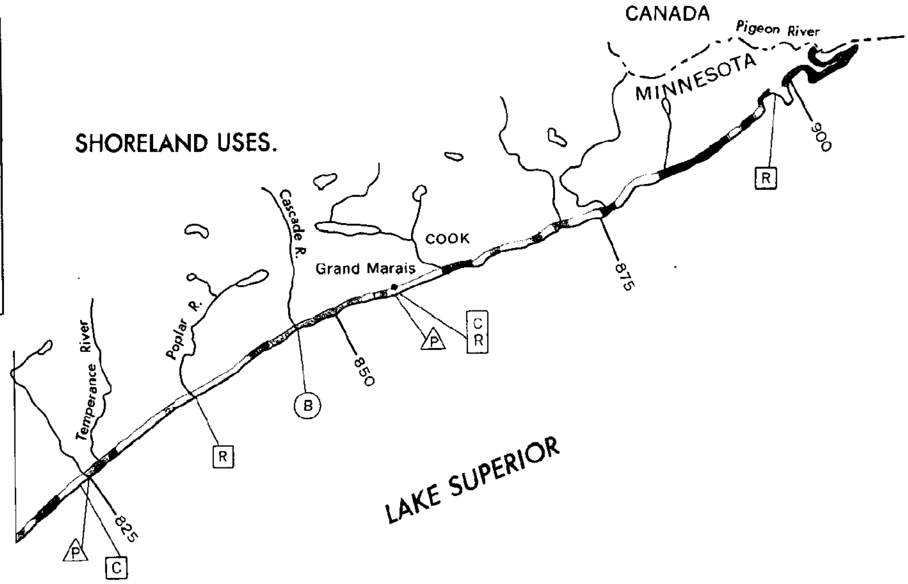
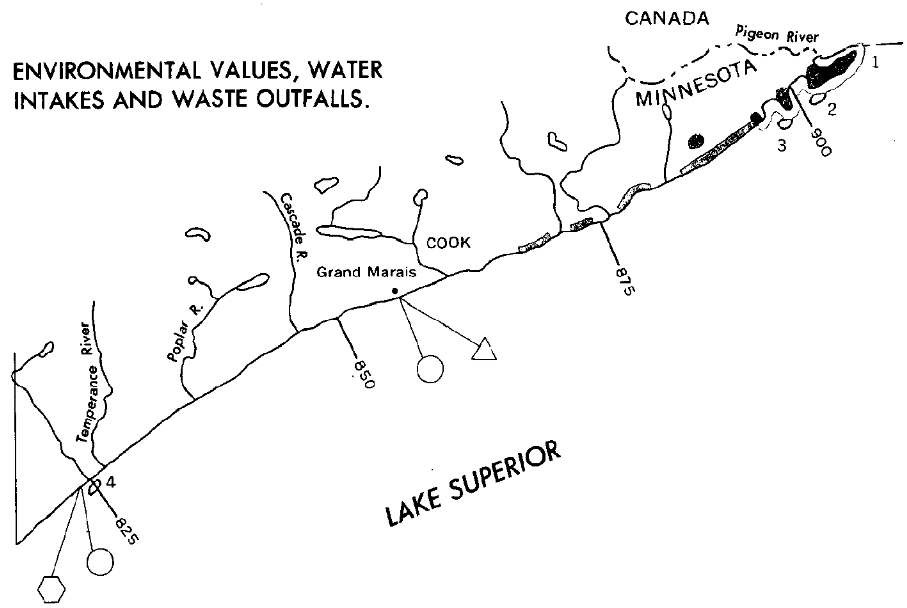
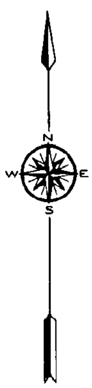
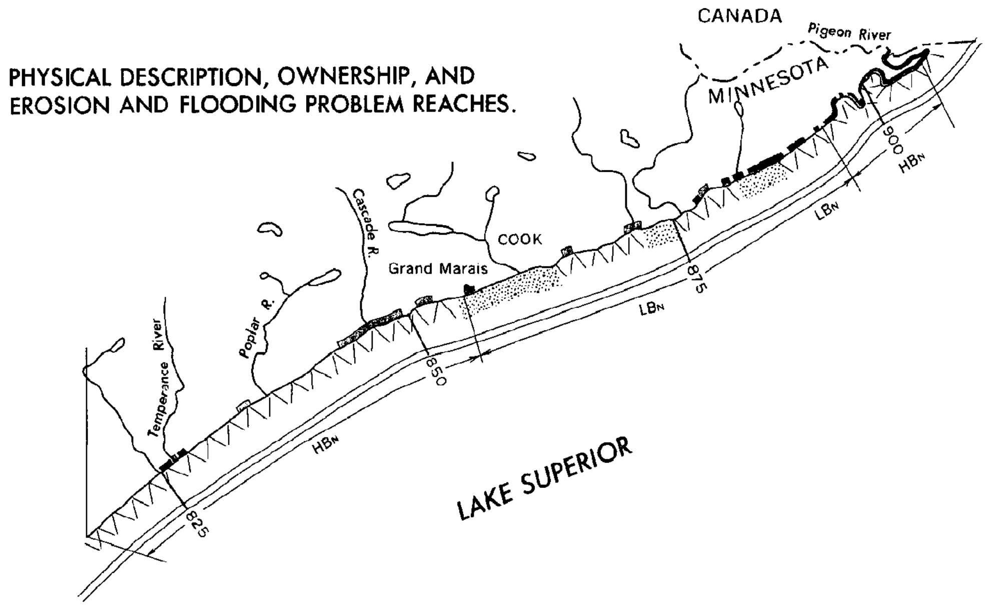










SHORELANDS OF THE GREAT LAKES, COOK COUNTY

LEGEND

SHORELAND USES

Commercial, Industrial, Residential and Public Buildings

Recreational and Urban Open Space

Agricultural and Undeveloped

Forest

Public Beaches — B

Commercial Deep Draft Harbors — C

Recreational Harbors — R

Commercial Deep Draft and Recreational Harbors — C R

Electric Power Stations — P

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

Significant Fish and Wildlife Values

Unique Ecological or Natural Areas

Outstanding Shoreland Areas of Possible National Interest

Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

Critical Bird Nesting and Migration Areas — 2 O

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

Federal Lands

Non-Federal Public Lands

Private Lands

Shore type

- Artificial Fill Area — A
- Erodible High Bluff, 30 ft. or higher — HB_E
- Non-Erodible High Bluff, 30 ft. or higher — HB_N
- Erodible Low Bluff, less than 30 ft. high — LB_E
- Non-Erodible Low Bluff, less than 30 ft. high — LB_N
- High Sand Dune, 30 ft. or higher — HD
- Low Sand Dune, less than 30 ft. high — LD
- Erodible Low Plain — P_E
- Non-Erodible Low Plain — P_N
- Wetlands — W

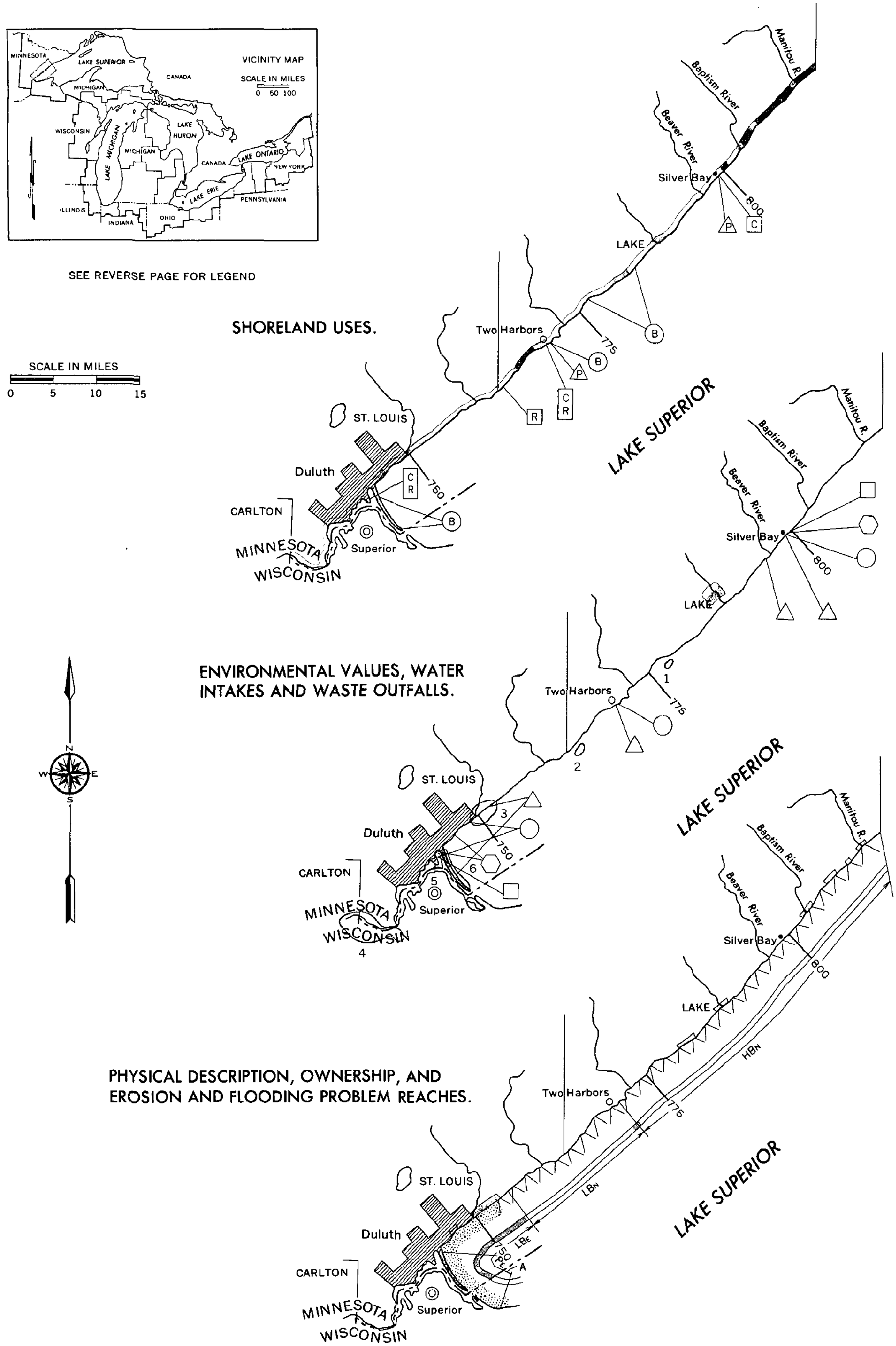
Combinations Shown As:	Example
Lakeward/Landward	W/P_E
$\frac{\text{Upper Bluff Material}}{\text{Lower Bluff Material}}$	$\frac{HB_E}{HB_N}$

Beach Material

- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems — S



SHORELANDS OF THE GREAT LAKES, CARLTON, ST. LOUIS, LAKE COUNTIES

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches — B
- Commercial Deep Draft Harbors — C
- Recreational Harbors — R
- Commercial Deep Draft and Recreational Harbors — C R
- Electric Power Stations — P

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

Critical Bird Nesting and Migration Areas — 2

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands

Shore type

Artificial Fill Area	A
Erodible High Bluff, 30 ft. or higher	HB_E
Non-Erodible High Bluff, 30 ft. or higher	HB_N
Erodible Low Bluff, less than 30 ft. high	LB_E
Non-Erodible Low Bluff, less than 30 ft. high	LB_N
High Sand Dune, 30 ft. or higher	HD
Low Sand Dune, less than 30 ft. high	LD
Erodible Low Plain	P_E
Non-Erodible Low Plain	P_N
Wetlands	W

Combinations Shown As:	Example
Lakeward/Landward	W/P_E
$\frac{\text{Upper Bluff Material}}{\text{Lower Bluff Material}}$	$\frac{HB_E}{HB_N}$

Beach Material

- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

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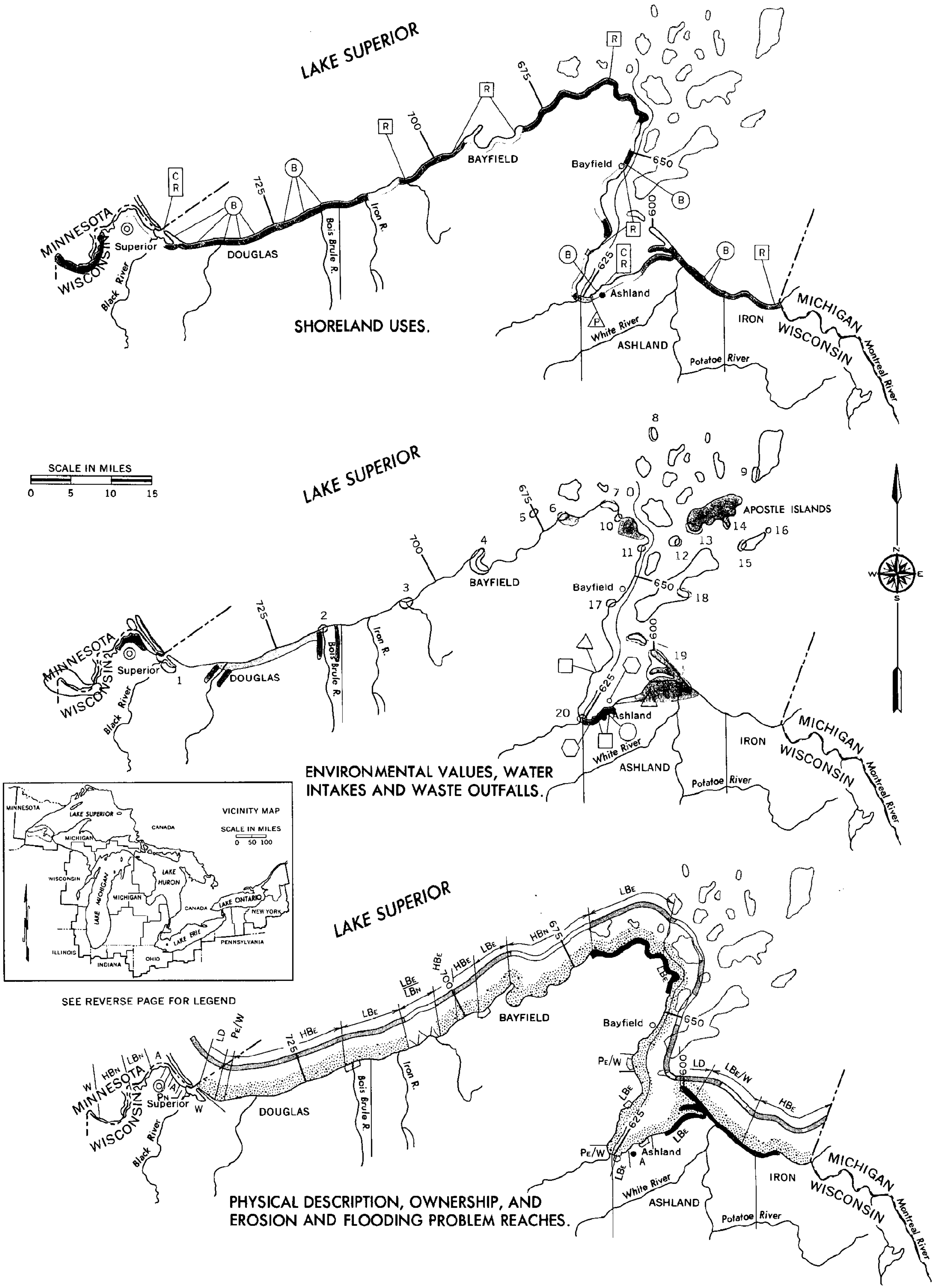
- Bluff seepage problems — S



SHORELANDS OF THE GREAT LAKES, IRON, ASHLAND, BAYFIELD, DOUGLAS COUNTIES

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches — B
- Commercial Deep Draft Harbors — C
- Recreational Harbors — R
- Commercial Deep Draft and Recreational Harbors — C R
- Electric Power Stations — P

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

Critical Bird Nesting and Migration Areas — 2

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands

Shore type

- Artificial Fill Area — A
- Erodible High Bluff, 30 ft. or higher — HB_E
- Non-Erodible High Bluff, 30 ft. or higher — HB_N
- Erodible Low Bluff, less than 30 ft. high — LB_E
- Non-Erodible Low Bluff, less than 30 ft. high — LB_N
- High Sand Dune, 30 ft. or higher — HD
- Low Sand Dune, less than 30 ft. high — LD
- Erodible Low Plain — P_E
- Non-Erodible Low Plain — P_N
- Wetlands — W

Combinations Shown As: Example

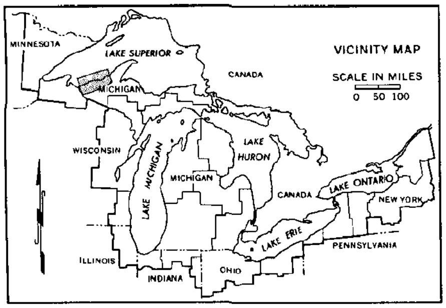
- Lakeward/Landward — W/P_E
- Upper Bluff Material / Lower Bluff Material — $\frac{HB_E}{HB_N}$

Beach Material

- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems — S



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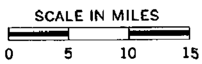
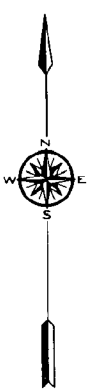
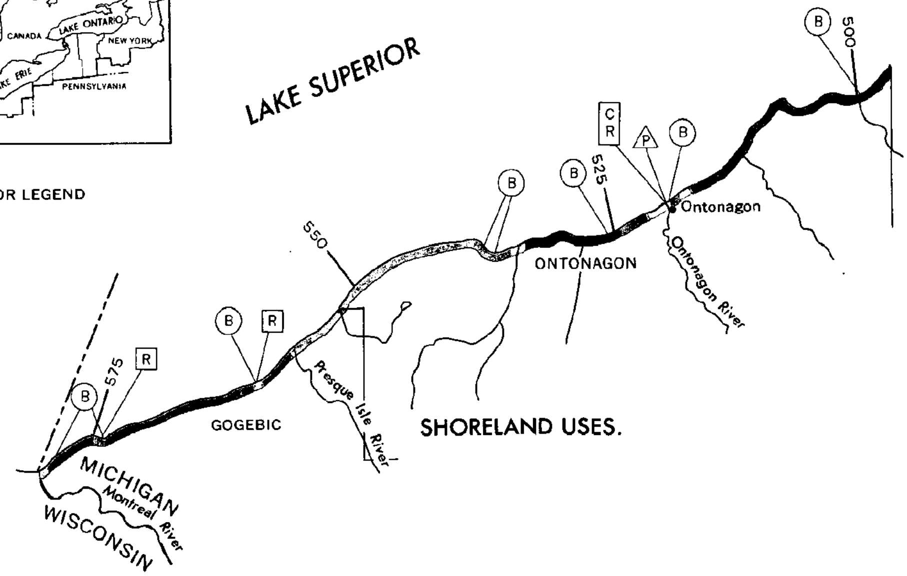
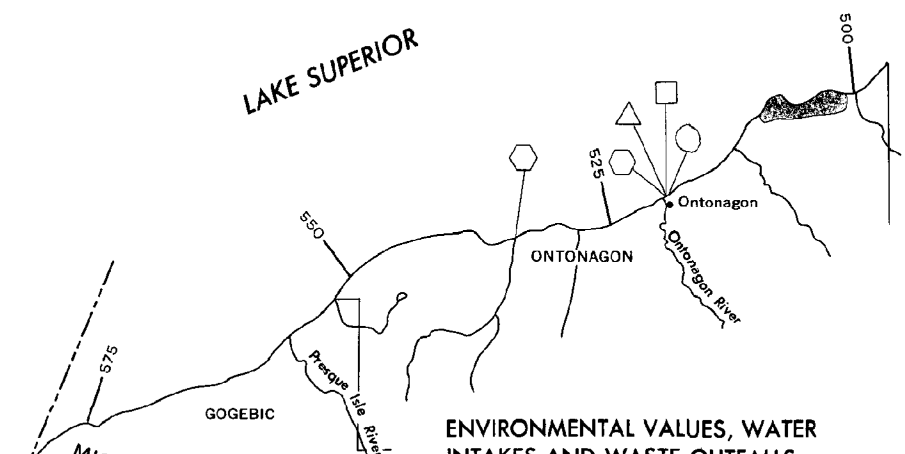


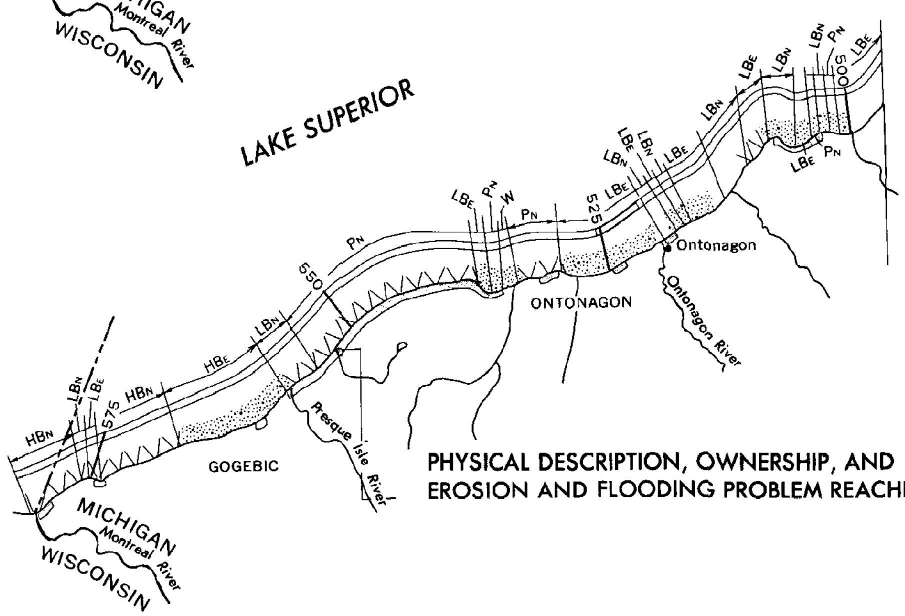




SHORELAND USES.



ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.



PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES.

SHORELANDS OF THE GREAT LAKES, ONTONAGON, GOGEBIC COUNTIES

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches — B
- Commercial Deep Draft Harbors — C
- Recreational Harbors — R
- Commercial Deep Draft and Recreational Harbors — C R
- Electric Power Stations — P

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

Critical Bird Nesting and Migration Areas — 2

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands

Shore type

Shore type	
Artificial Fill Area	A
Erodible High Bluff, 30 ft. or higher	HB_E
Non-Erodible High Bluff, 30 ft. or higher	HB_N
Erodible Low Bluff, less than 30 ft. high	LB_E
Non-Erodible Low Bluff, less than 30 ft. high	LB_N
High Sand Dune, 30 ft. or higher	HD
Low Sand Dune, less than 30 ft. high	LD
Erodible Low Plain	P_E
Non-Erodible Low Plain	P_N
Wetlands	W

Combinations Shown As:	Example
Lakeward/Landward	W/P_E
$\frac{\text{Upper Bluff Material}}{\text{Lower Bluff Material}}$	$\frac{HB_E}{HB_N}$

Beach Material

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- Ledge rock
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Problem Identification

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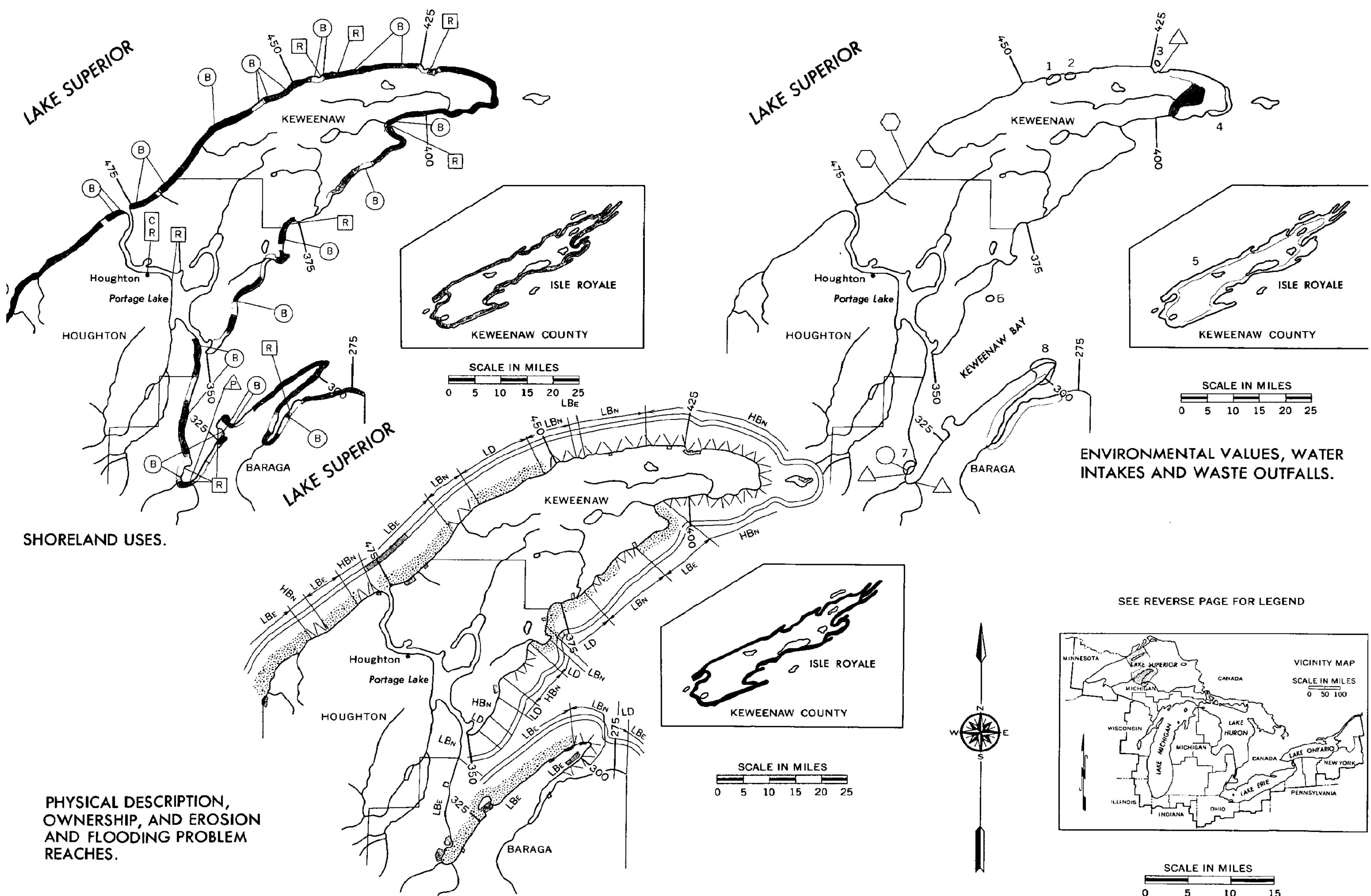

SHORELANDS OF THE GREAT LAKES, BARAGA, HOUGHTON, KEWEENAW COUNTIES

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches — B
- Commercial Deep Draft Harbors — C
- Recreational Harbors — R
- Commercial Deep Draft and Recreational Harbors — C R
- Electric Power Stations — P

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
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- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

Critical Bird Nesting and Migration Areas — 2

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands

Shore type

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- Low Sand Dune, less than 30 ft. high — LD
- Erodible Low Plain — P_E
- Non-Erodible Low Plain — P_N
- Wetlands — W

Combinations Shown As: Example

- Lakeward/Landward — W/P_E
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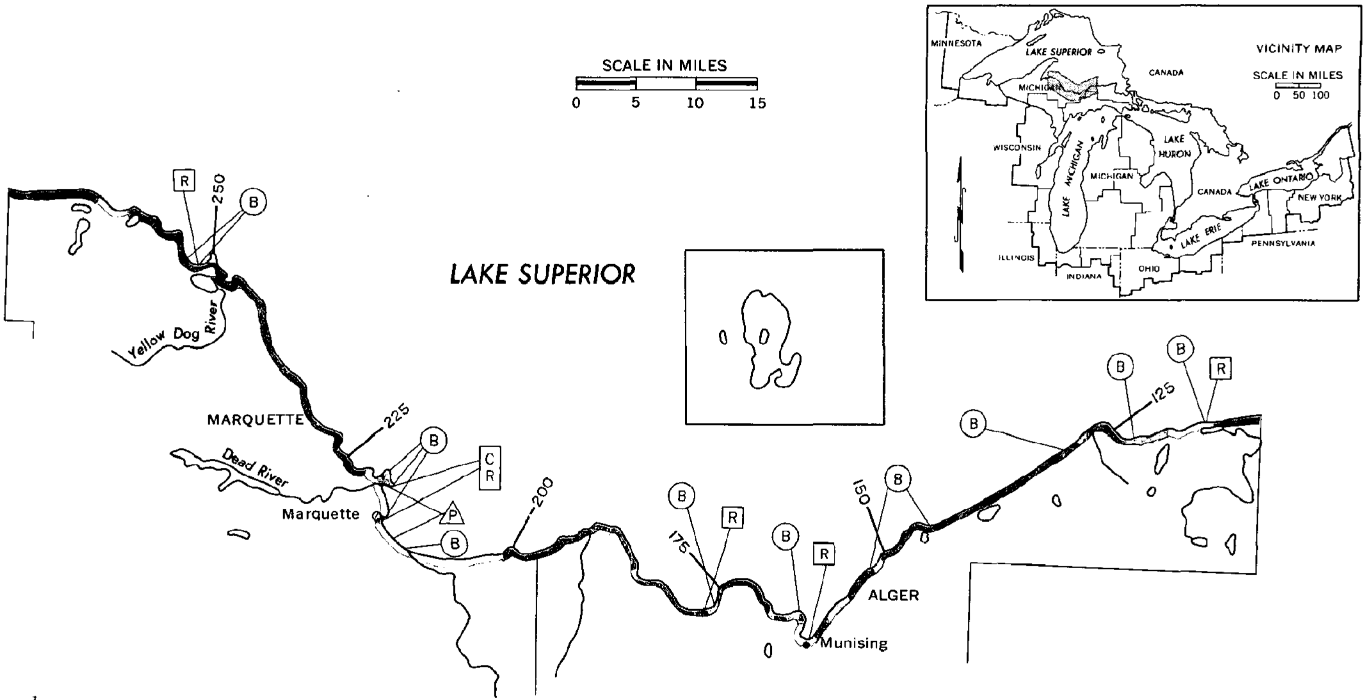
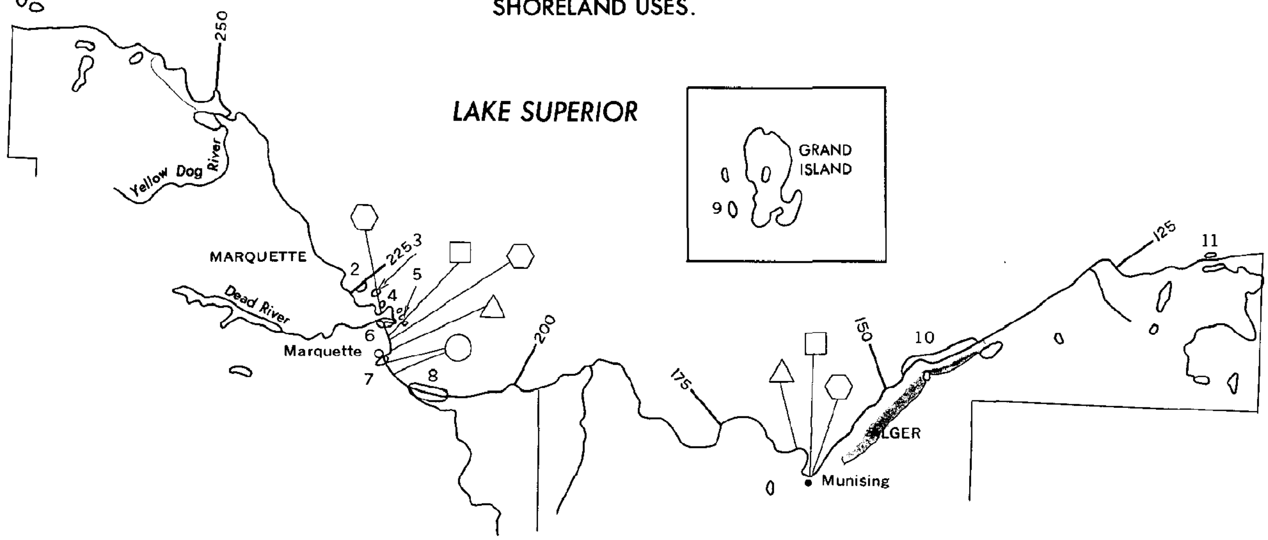
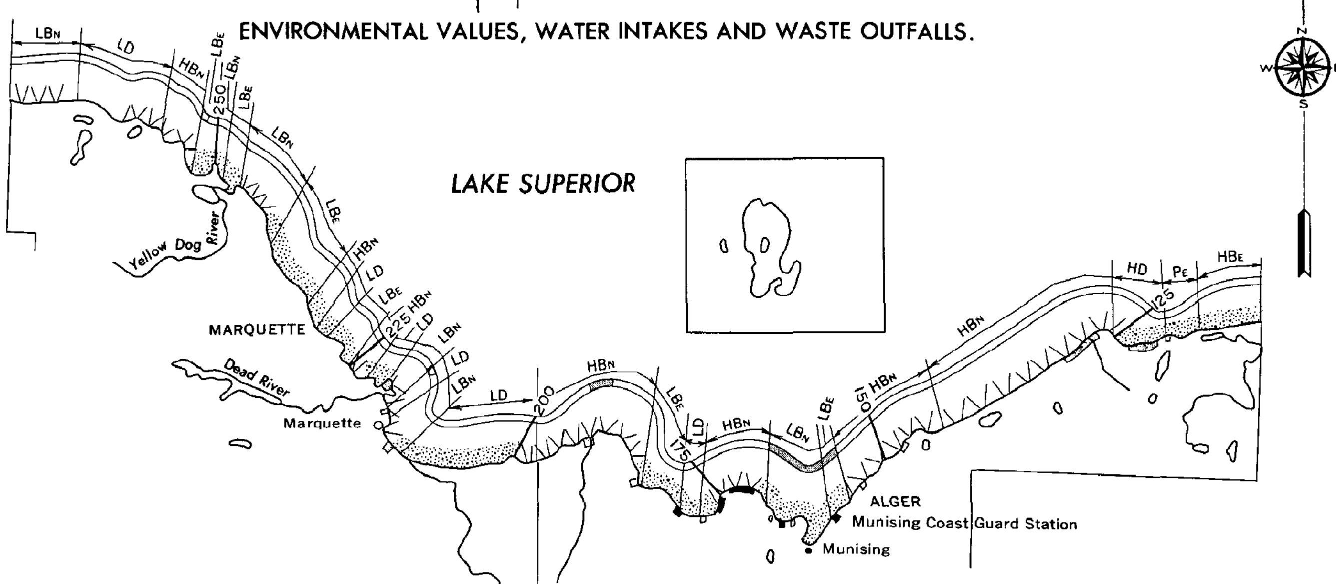


SHORELAND USES.



ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.



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PHYSICAL DESCRIPTION, OWNERSHIP, AND
EROSION AND FLOODING PROBLEM REACHES.

SHORELANDS OF THE GREAT LAKES, MARQUETTE, ALGER COUNTIES

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches — B
- Commercial Deep Draft Harbors — C
- Recreational Harbors — R
- Commercial Deep Draft and Recreational Harbors — C R
- Electric Power Stations — P

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

Critical Bird Nesting and Migration Areas — 2

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands

Shore type

Artificial Fill Area	A
Erodible High Bluff, 30 ft. or higher	HBE
Non-Erodible High Bluff, 30 ft. or higher	HBN
Erodible Low Bluff, less than 30 ft. high	LBE
Non-Erodible Low Bluff, less than 30 ft. high	LBN
High Sand Dune, 30 ft. or higher	HD
Low Sand Dune, less than 30 ft. high	LD
Erodible Low Plain	PE
Non-Erodible Low Plain	PN
Wetlands	W
Combinations Shown As:	Example
Lakeward/Landward	W/PE
Upper Bluff Material / Lower Bluff Material	HBE / HBN

Beach Material

- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
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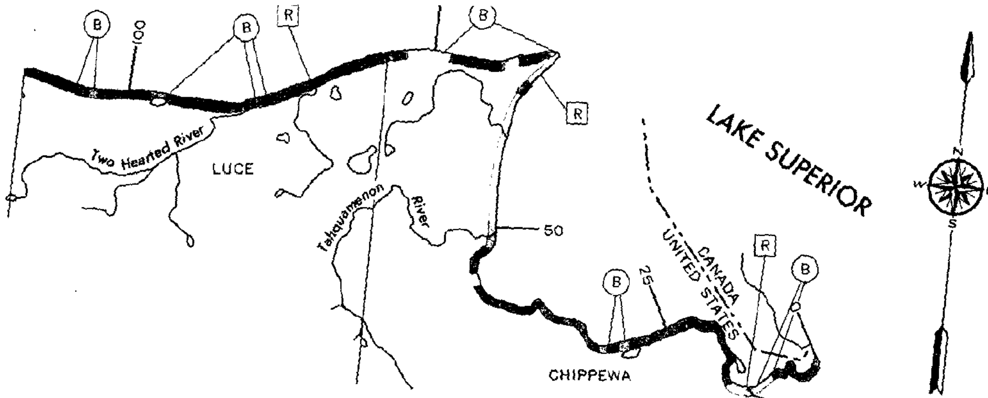
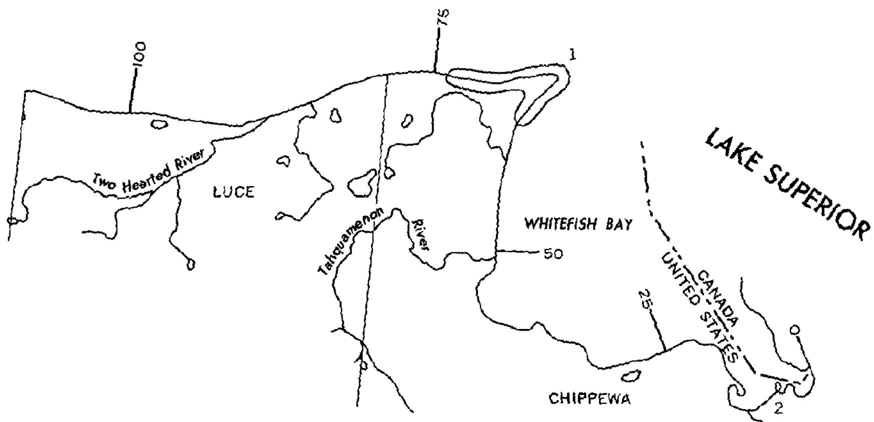
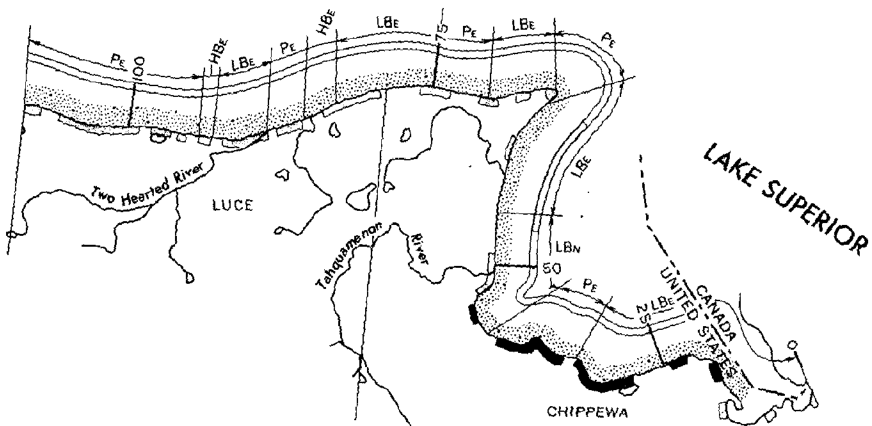
- Bluff seepage problems — S



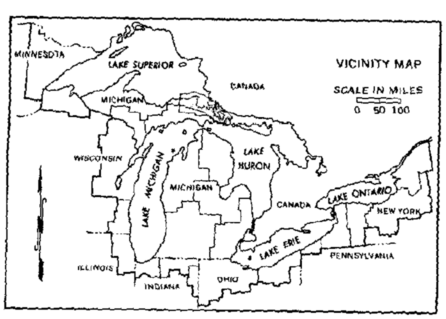
SHORELAND USES.

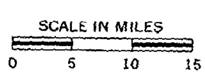


ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.



PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES.





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...ELANDS OF THE GREAT LAKES, CHIPPEWA, LUCE COUNTIES

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches — B
- Commercial Deep Draft Harbors — C
- Recreational Harbors — R
- Commercial Deep Draft and Recreational Harbors — C R
- Electric Power Stations — P

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
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- Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

Critical Bird Nesting and Migration Areas — 2

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands

Shore type

- Artificial Fill Area — A
- Erodible High Bluff, 30 ft. or higher — HB_E
- Non-Erodible High Bluff, 30 ft. or higher — HB_N
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- High Sand Dune, 30 ft. or higher — HD
- Low Sand Dune, less than 30 ft. high — LD
- Erodible Low Plain — P_E
- Non-Erodible Low Plain — P_N
- Wetlands — W

Combinations Shown As: Example

- Lakeward/Landward — W/P_E
- Upper Bluff Material / Lower Bluff Material — $\frac{HB_E}{HB_N}$

Beach Material

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- Ledge rock
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Problem Identification

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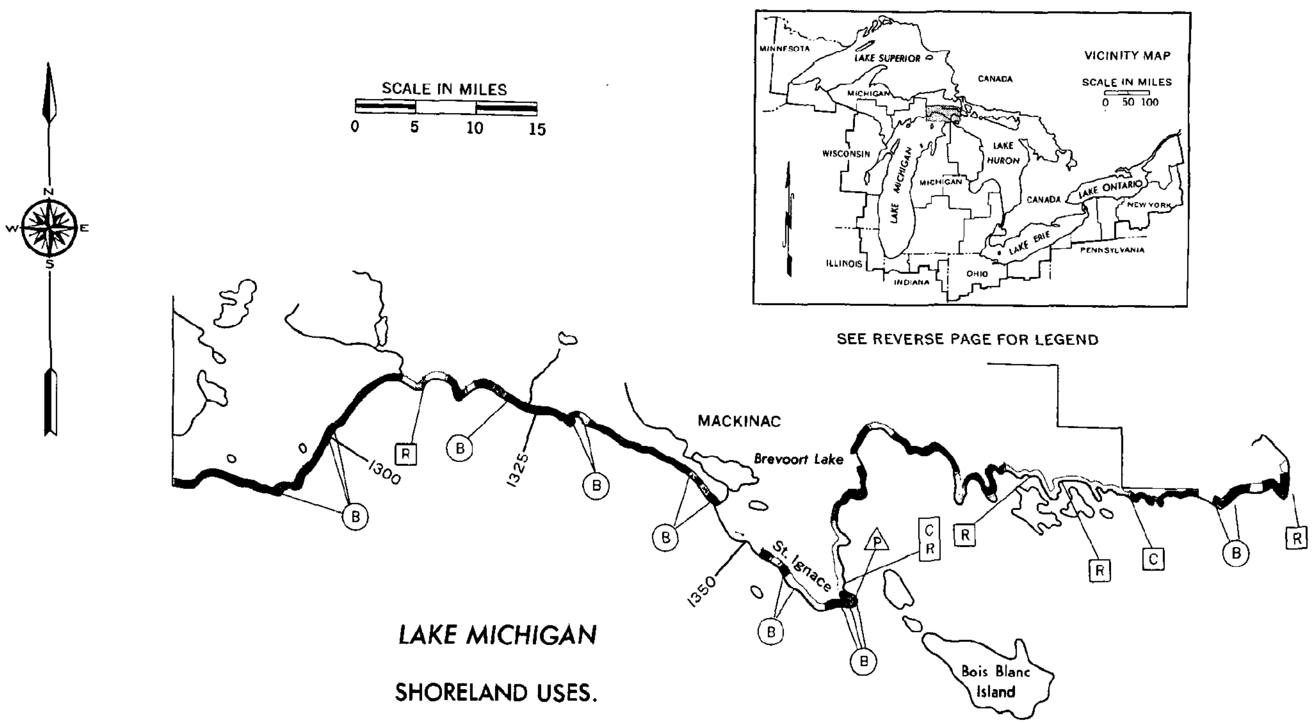
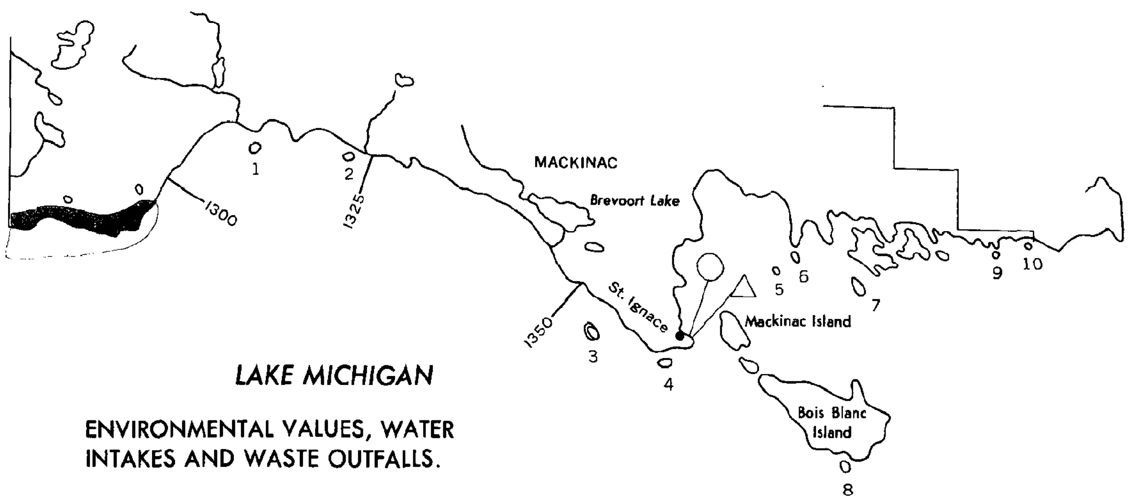
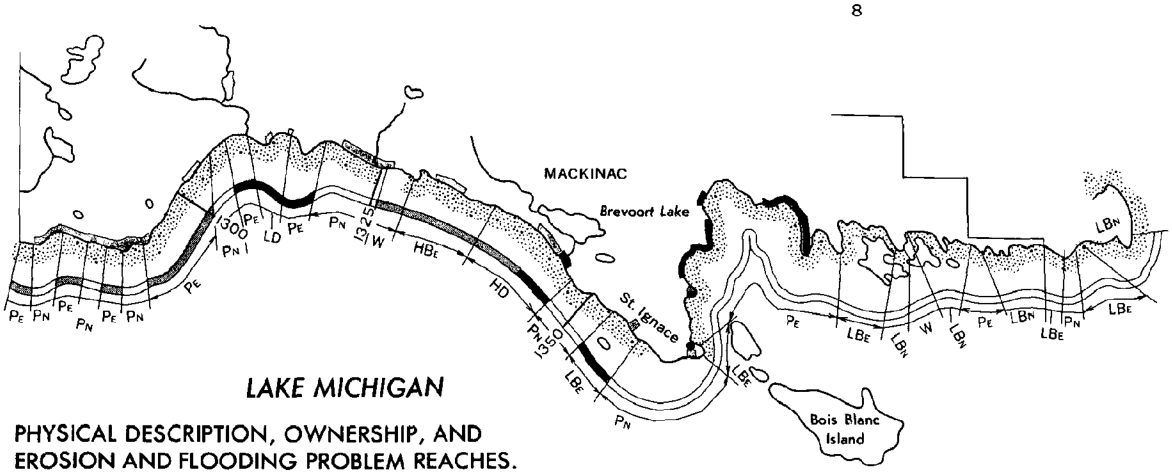






SHORELANDS OF THE GREAT LAKES, MACKINAC COUNTY AND CHIPPEWA COUNTY, EAST TO BRUSH POINT

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches — B
- Commercial Deep Draft Harbors — C
- Recreational Harbors — R
- Commercial Deep Draft and Recreational Harbors — C R
- Electric Power Stations — P

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

Critical Bird Nesting and Migration Areas — 2

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands

Shore type

- Artificial Fill Area — A
- Erodible High Bluff, 30 ft. or higher — HB_E
- Non-Erodible High Bluff, 30 ft. or higher — HB_N
- Erodible Low Bluff, less than 30 ft. high — LB_E
- Non-Erodible Low Bluff, less than 30 ft. high — LB_N
- High Sand Dune, 30 ft. or higher — HD
- Low Sand Dune, less than 30 ft. high — LD
- Erodible Low Plain — P_E
- Non-Erodible Low Plain — P_N
- Wetlands — W

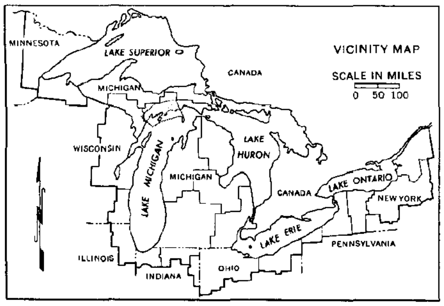
Combinations Shown As:	Example
Lakeward/Landward	W/P_E
$\frac{\text{Upper Bluff Material}}{\text{Lower Bluff Material}}$	$\frac{HB_E}{HB_N}$

Beach Material

- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems — S



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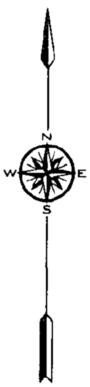
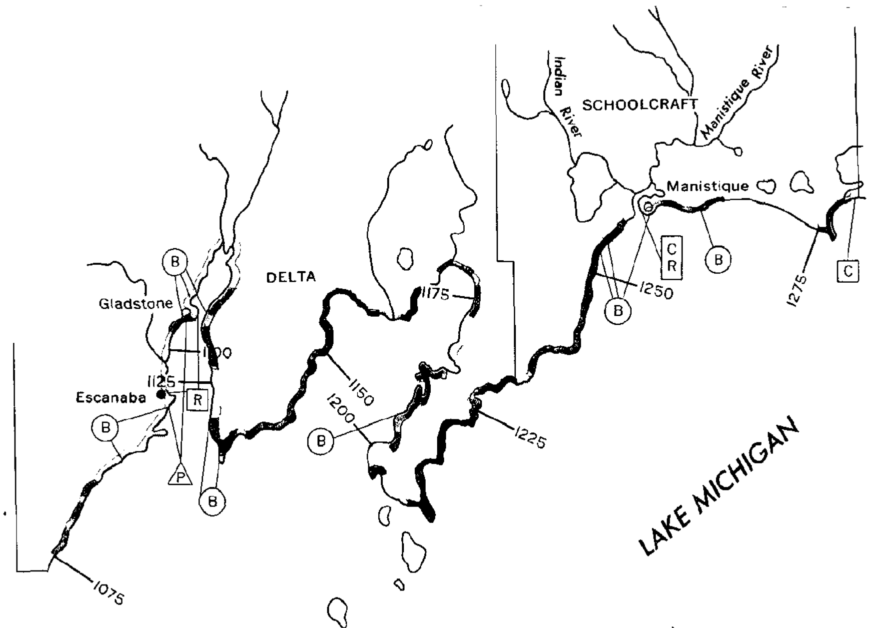
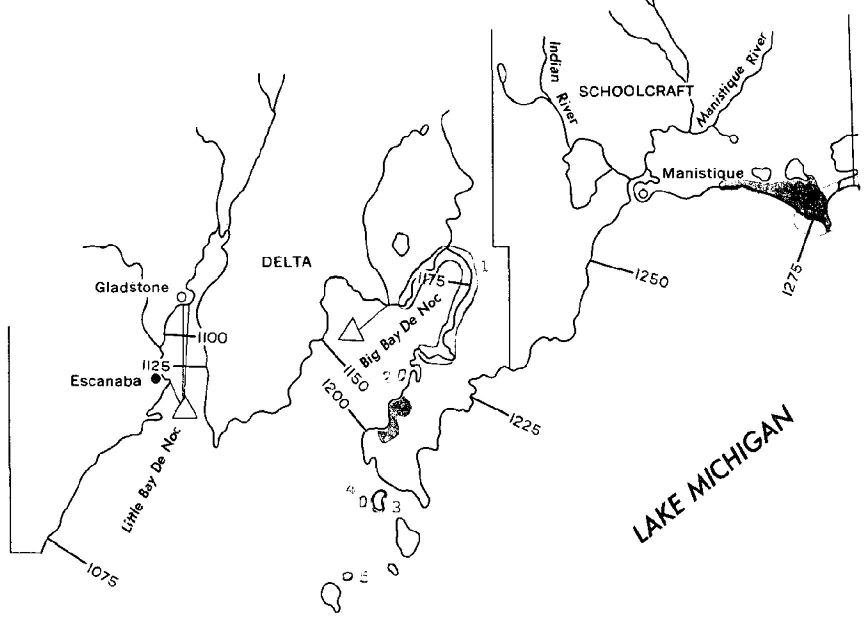


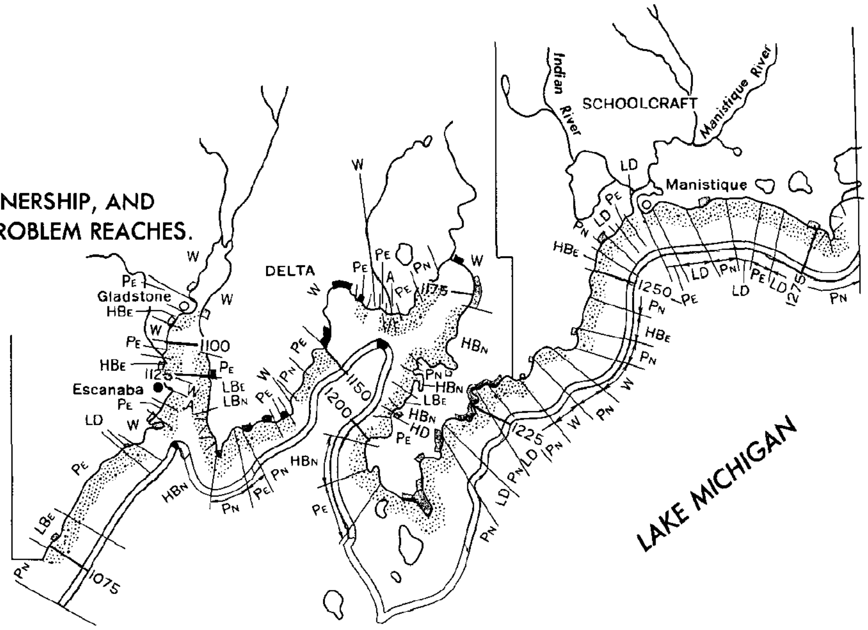


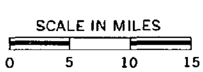
SHORELAND USES.



ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES.





SHORELANDS OF THE GREAT LAKES, SCHOOLCRAFT, DELTA COUNTIES

LEGEND

SHORELAND USES

Commercial, Industrial, Residential and Public Buildings

Recreational and Urban Open Space

Agricultural and Undeveloped

Forest

Public Beaches — B

Commercial Deep Draft Harbors — C

Recreational Harbors — R

Commercial Deep Draft and Recreational Harbors — C R

Electric Power Stations — P

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

Significant Fish and Wildlife Values

Unique Ecological or Natural Areas

Outstanding Shoreland Areas of Possible National Interest

Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

Critical Bird Nesting and Migration Areas — 2

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

Federal Lands

Non-Federal Public Lands

Private Lands

Shore type

Artificial Fill Area	A
Erodible High Bluff, 30 ft. or higher	HB_E
Non-Erodible High Bluff, 30 ft. or higher	HB_N
Erodible Low Bluff, less than 30 ft. high	LB_E
Non-Erodible Low Bluff, less than 30 ft. high	LB_N
High Sand Dune, 30 ft. or higher	HD
Low Sand Dune, less than 30 ft. high	LD
Erodible Low Plain	P_E
Non-Erodible Low Plain	P_N
Wetlands	W

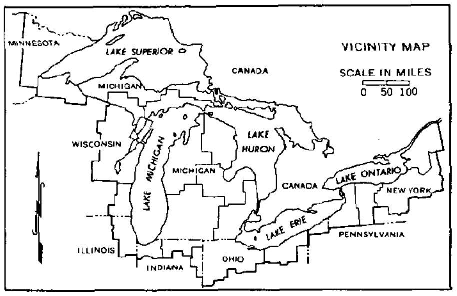
Combinations Shown As:	Example
Lakeward/Landward	W/P_E
Upper Bluff Material / Lower Bluff Material	$\frac{HB_E}{HB_N}$

Beach Material

- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake *flooding*
- Shoreline not subject to erosion or flooding
- Bluff seepage problems — S



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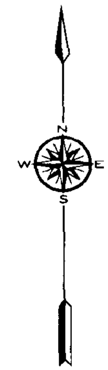
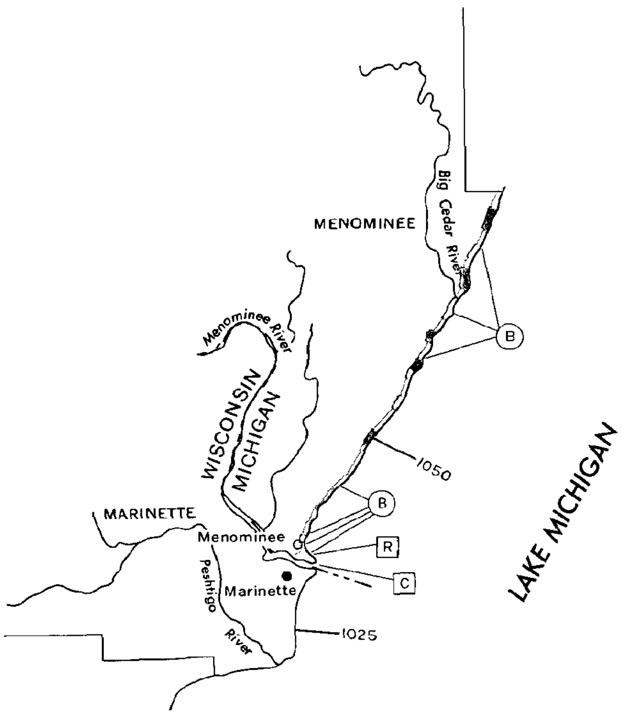
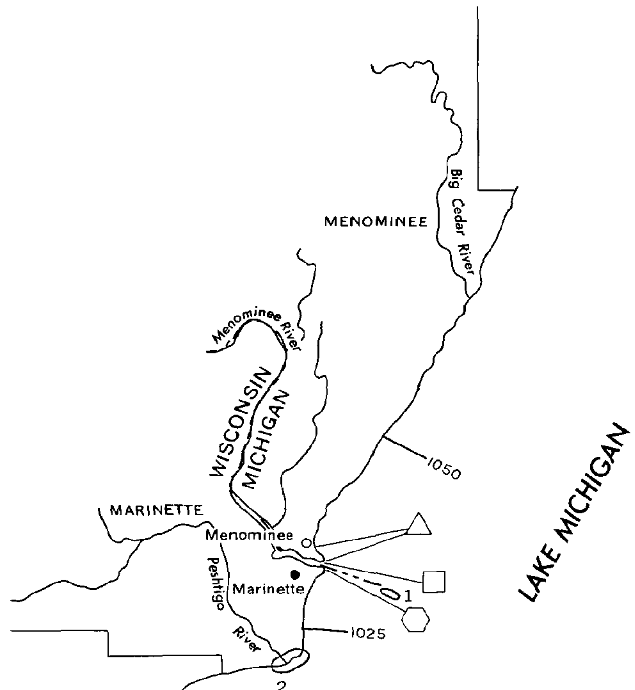
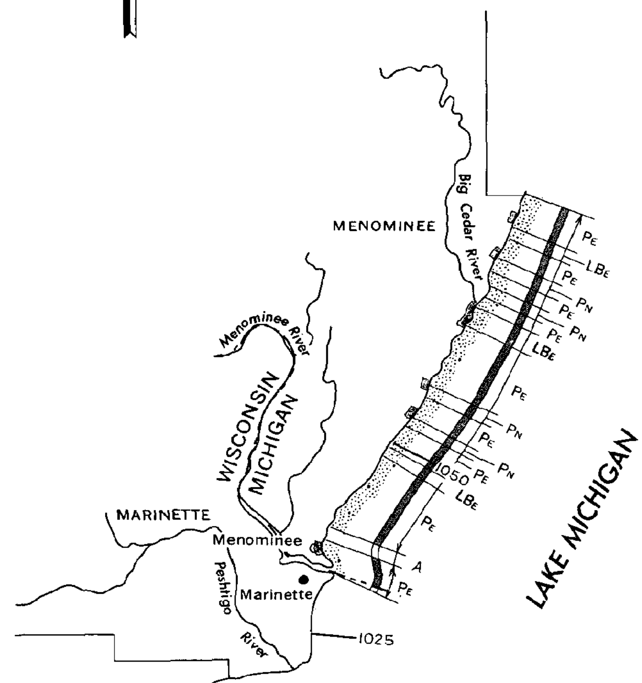




SHORELAND USES.



ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.



PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES.

SHORELANDS OF THE GREAT LAKES, MENOMINEE, COUNTY

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches — B
- Commercial Deep Draft Harbors — C
- Recreational Harbors — R
- *Commercial Deep Draft and* Recreational Harbors — C R
- Electric Power Stations — P

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

Critical Bird Nesting and Migration Areas — 2

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands

Shore type

Artificial Fill Area	A
Erodible High Bluff, 30 ft. or higher	HB_E
Non-Erodible High Bluff, 30 ft. or higher	HB_N
Erodible Low Bluff, less than 30 ft. high	LB_E
Non-Erodible Low Bluff, less than 30 ft. high	LB_N
High Sand Dune, 30 ft. or higher	HD
Low Sand Dune, less than 30 ft. high	LD
Erodible Low Plain	P_E
Non-Erodible Low Plain	P_N
Wetlands	W

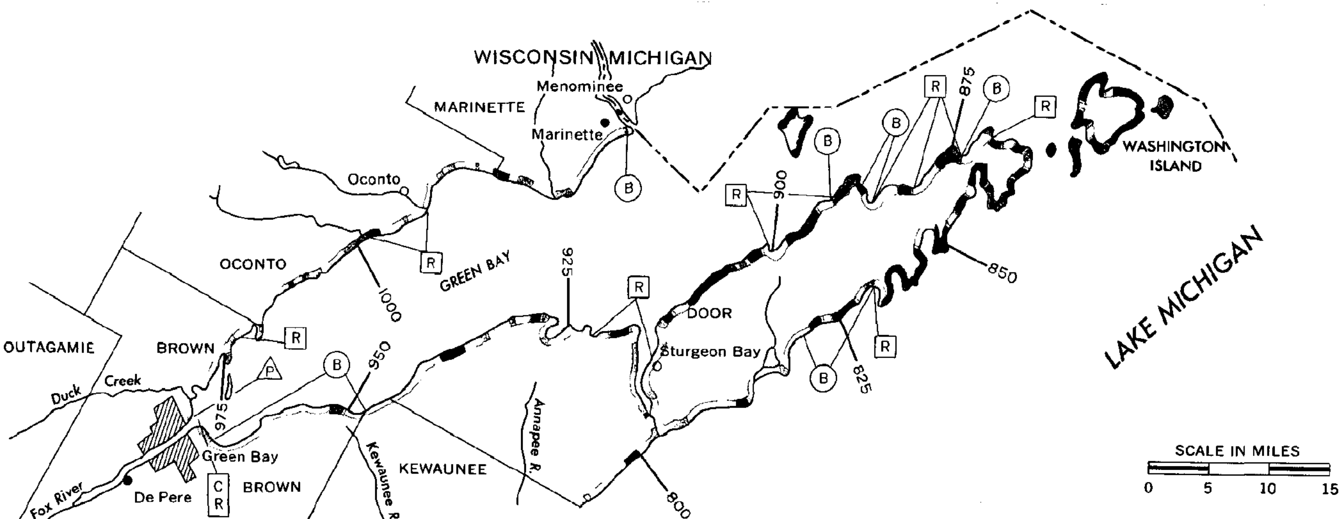
Combinations Shown As:	Example
Lakeward/Landward	W/P_E
Upper Bluff Material / Lower Bluff Material	$\frac{HB_E}{HB_N}$

Beach Material

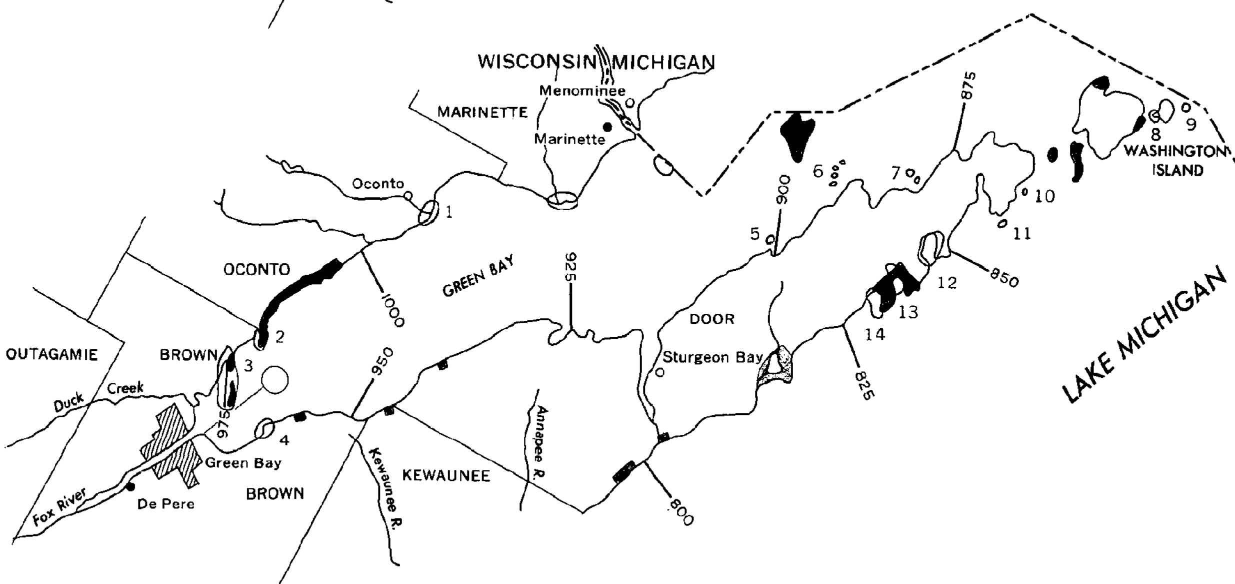
- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

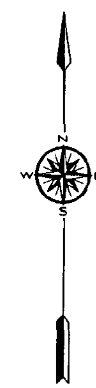
- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems — S

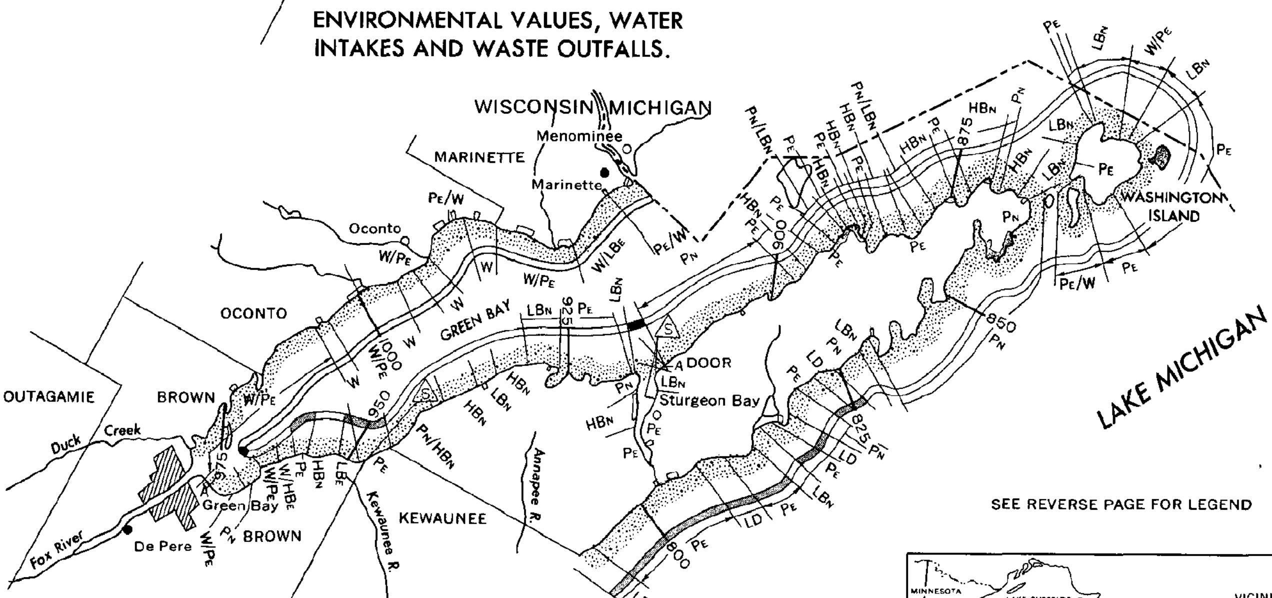


SHORELAND USES.



ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.





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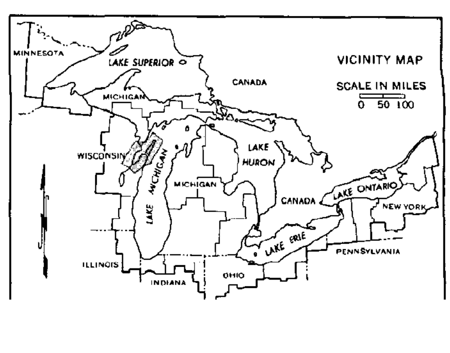
PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES.



SHORELANDS OF THE GREAT LAKES, MARINETTE, OCONTO, BROWN, KEWAUNEE, DOOR COUNTIES

LEGEND

SHORELAND USES

Commercial, Industrial, Residential and Public Buildings

Recreational and Urban Open Space

Agricultural and Undeveloped

Forest

Public Beaches — (B)

Commercial Deep Draft Harbors — C

Recreational Harbors — R

Commercial Deep Draft and Recreational Harbors — C R

Electric Power Stations — P

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

Significant Fish and Wildlife Values

Unique Ecological or Natural Areas

Outstanding Shoreland Areas of Possible National Interest

Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

Critical Bird Nesting and Migration Areas — 2 O

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

Federal Lands

Non-Federal Public Lands

Private Lands

Shore type

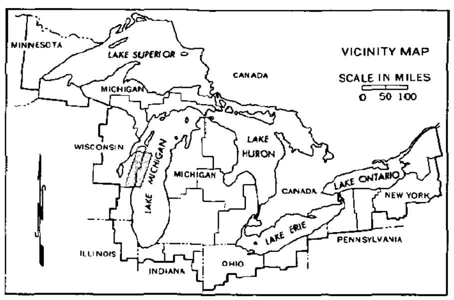
Artificial Fill Area	A
Erodible High Bluff, 30 ft. or higher	HB_E
Non-Erodible High Bluff, 30 ft. or higher	HB_N
Erodible Low Bluff, less than 30 ft. high	LB_E
Non-Erodible Low Bluff, less than 30 ft. high	LB_N
High Sand Dune, 30 ft. or higher	HD
Low Sand Dune, less than 30 ft. high	LD
Erodible Low Plain	P_E
Non-Erodible Low Plain	P_N
Wetlands	W
Combinations Shown As:	Example
Lakeward/Landward	W/P_E
Upper Bluff Material / Lower Bluff Material	$\frac{HB_E}{HB_N}$

Beach Material

- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems — S



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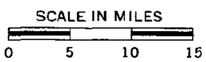
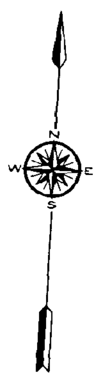
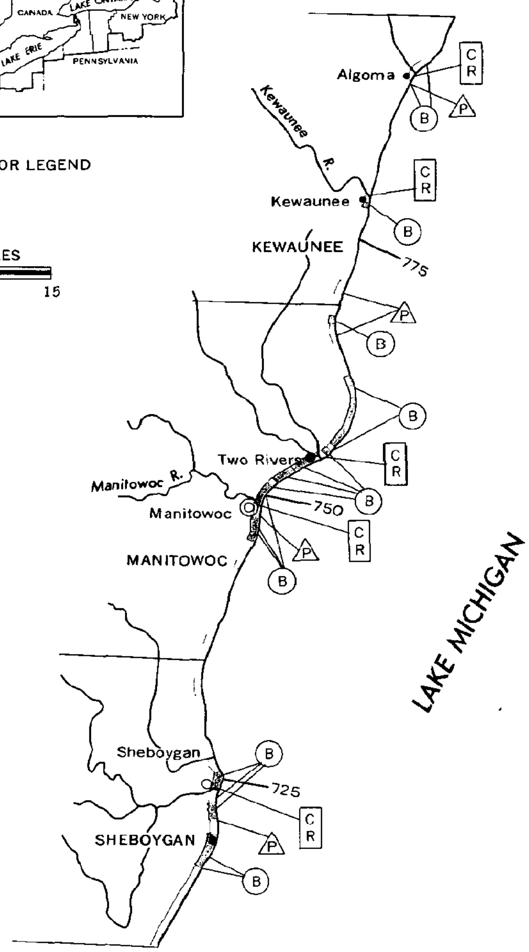
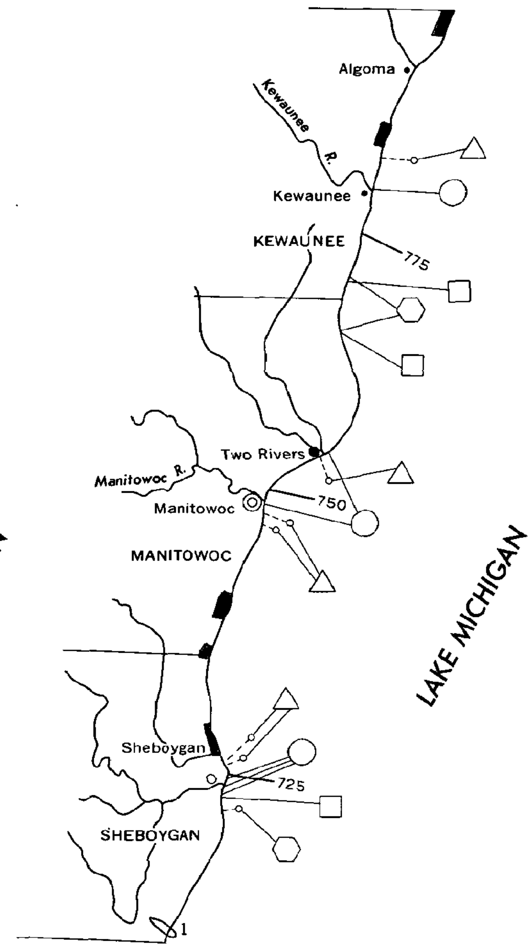


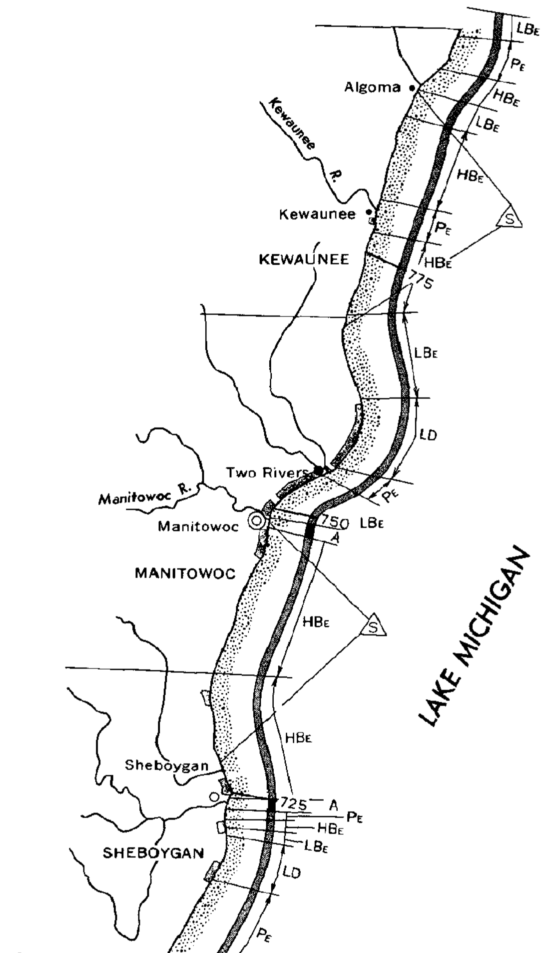




SHORELAND USES.



ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.



PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES.

SHORELANDS OF THE GREAT LAKES, SHEBOYGAN, MANITOWOC, KEWAUNEE COUNTIES

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches — B
- Commercial Deep Draft Harbors — C
- Recreational Harbors — R
- Commercial Deep Draft and Recreational Harbors — C R
- Electric Power Stations — P

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

Critical Bird Nesting and Migration Areas — 2 O

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands

Shore type

- Artificial Fill Area — A
- Erodible High Bluff, 30 ft. or higher — HB_E
- Non-Erodible High Bluff, 30 ft. or higher — HB_N
- Erodible Low Bluff, less than 30 ft. high — LB_E
- Non-Erodible Low Bluff, less than 30 ft. high — LB_N
- High Sand Dune, 30 ft. or higher — HD
- Low Sand Dune, less than 30 ft. high — LD
- Erodible Low Plain — P_E
- Non-Erodible Low Plain — P_N
- Wetlands — W

Combinations Shown As: Example

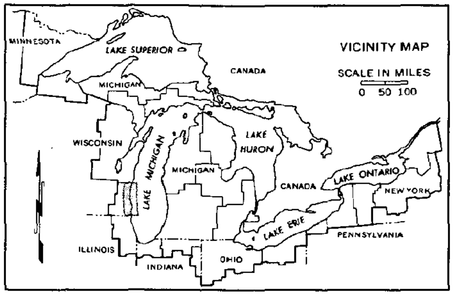
- Lakeward/Landward — W/P_E
- $\frac{\text{Upper Bluff Material}}{\text{Lower Bluff Material}}$ — $\frac{HB_E}{HB_N}$

Beach Material

- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems — S



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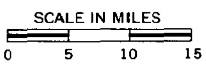
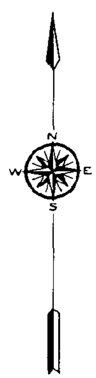
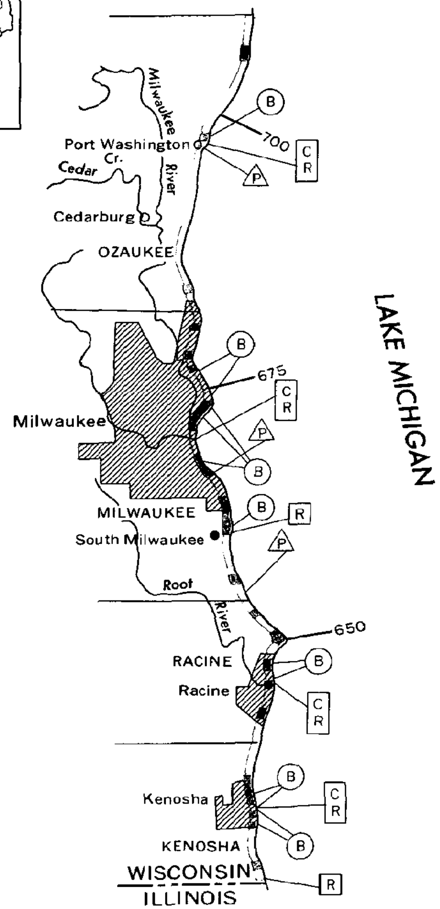
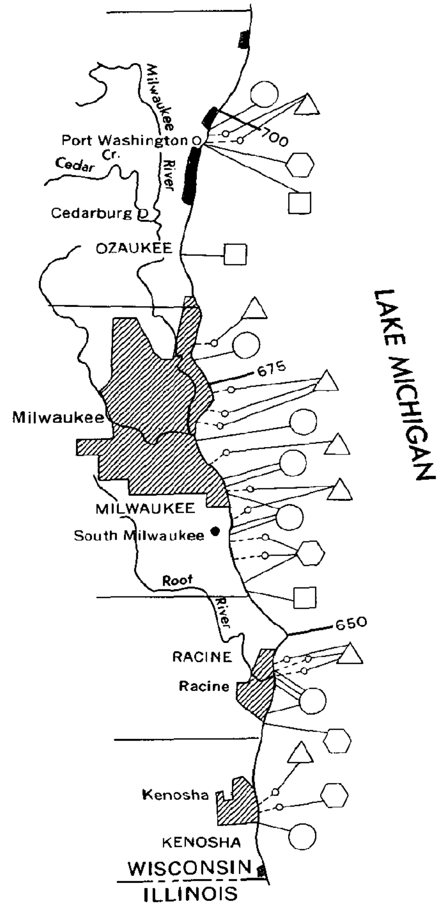


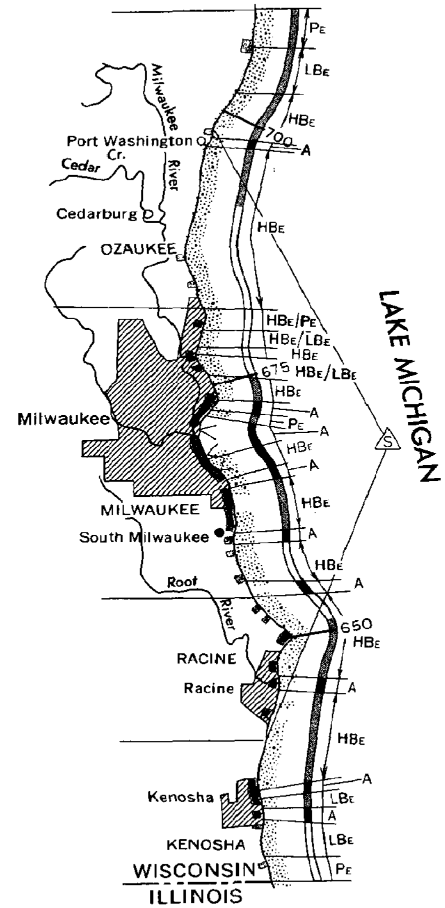




SHORELAND USES.



ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.



PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES.

SHORELANDS OF THE GREAT LAKES, OZAUKEE, MILWAUKEE, RACINE, KENOSHA COUNTIES

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches — B
- Commercial Deep Draft Harbors — C
- Recreational Harbors — R
- Commercial Deep Draft and Recreational Harbors — C R
- Electric Power Stations — P

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

Critical Bird Nesting and Migration Areas — 2

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands

Shore type

- Artificial Fill Area — A
- Erodible High Bluff, 30 ft. or higher — HB_E
- Non-Erodible High Bluff, 30 ft. or higher — HB_N
- Erodible Low Bluff, less than 30 ft. high — LB_E
- Non-Erodible Low Bluff, less than 30 ft. high — LB_N
- High Sand Dune, 30 ft. or higher — HD
- Low Sand Dune, less than 30 ft. high — LD
- Erodible Low Plain — P_E
- Non-Erodible Low Plain — P_N
- Wetlands — W

Combinations Shown As: — Example

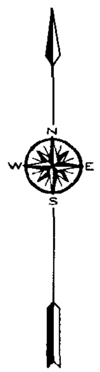
- Lakeward/Landward — W/P_E
- Upper Bluff Material / Lower Bluff Material — $\frac{HB_E}{HB_N}$

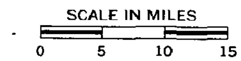
Beach Material

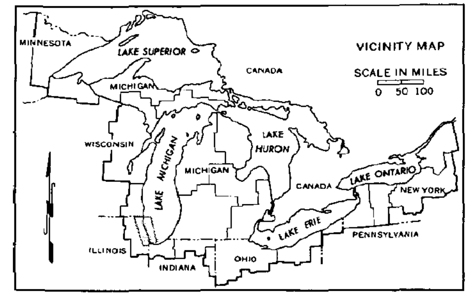
- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems — S







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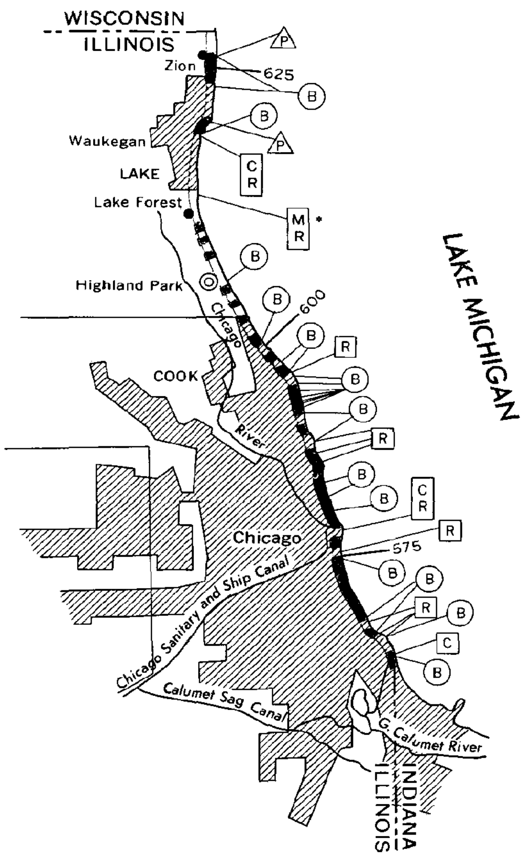
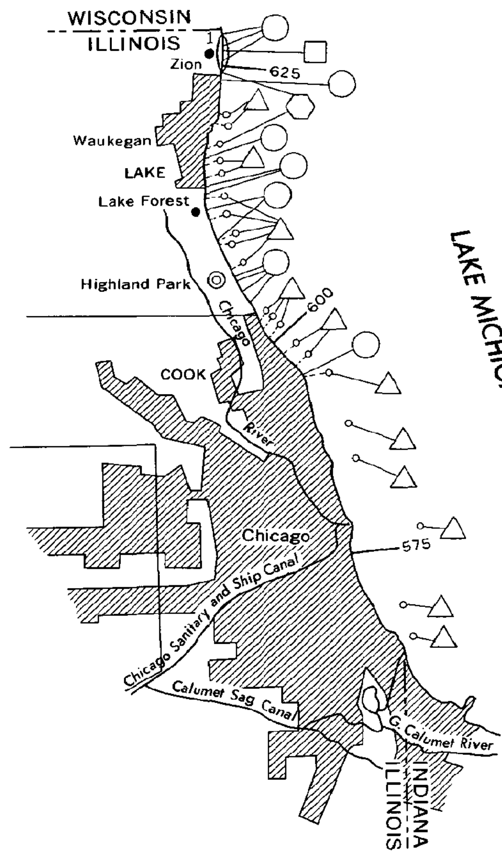
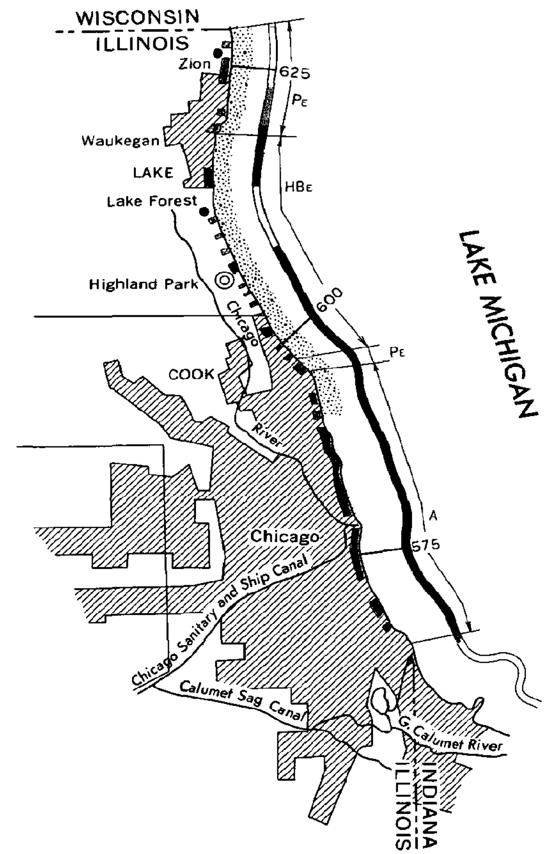


SHORELAND USES.



ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.



PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES.

*M—Military Harbor

SHORELANDS OF THE GREAT LAKES, LAKE, COOK COUNTIES

LEGEND

SHORELAND USES

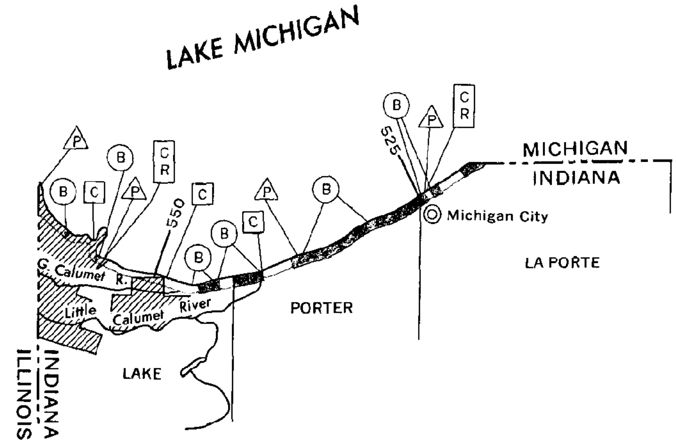
Commercial, Industrial, Residential and Public Buildings	
Recreational and Urban Open Space	
Agricultural and Undeveloped	
Forest	
Public Beaches	B
Commercial Deep Draft Harbors	C
Recreational Harbors	R
Commercial Deep Draft and Recreational Harbors	C R
Electric Power Stations	P

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

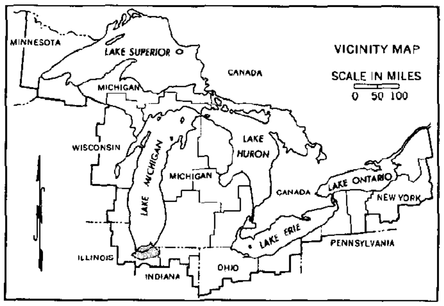
Significant Fish and Wildlife Values	
Unique Ecological or Natural Areas	
Outstanding Shoreland Areas of Possible National Interest	
Potential Recreation Sites	
Waste Water Outfalls and Intakes	
Public Outfalls	
Public Intakes	
Private Outfalls	
Private Intakes	
Critical Bird Nesting and Migration Areas	2 O

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

Federal Lands	
Non-Federal Public Lands	
Private Lands	
Shore type	
Artificial Fill Area	A
Erodible High Bluff, 30 ft. or higher	HB_E
Non-Erodible High Bluff, 30 ft. or higher	HB_N
Erodible Low Bluff, less than 30 ft. high	LB_E
Non-Erodible Low Bluff, less than 30 ft. high	LB_N
High Sand Dune, 30 ft. or higher	HD
Low Sand Dune, less than 30 ft. high	LD
Erodible Low Plain	P_E
Non-Erodible Low Plain	P_N
Wetlands	W
Combinations Shown As:	Example
Lakeward/Landward	W/P_E
$\frac{\text{Upper Bluff Material}}{\text{Lower Bluff Material}}$	$\frac{HB_E}{HB_N}$
Beach Material	
Sand and gravel	
Ledge rock	
No Beach	
Problem Identification	
Areas subject to erosion generally protected	
Critical erosion areas not protected	
Non-critical erosion areas not protected	
Shoreline subject to lake flooding	
Shoreline not subject to erosion or flooding	
Bluff seepage problems	S



SHORELAND USES.



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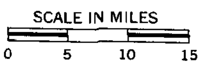
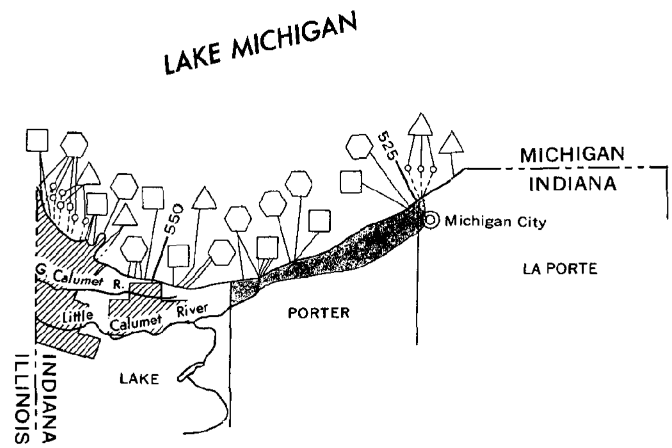
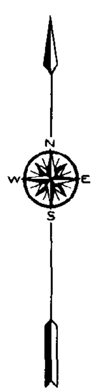
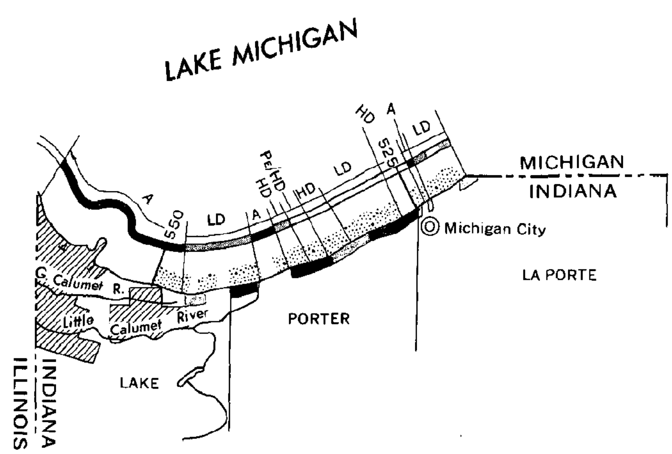




ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.





PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES.

SHORELANDS OF THE GREAT LAKES, LAKE, PORTER, LA PORTE COUNTIES

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches — B
- Commercial Deep Draft Harbors — C
- Recreational Harbors — R
- Commercial Deep Draft and Recreational Harbors — C R
- Electric Power Stations — P

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

Critical Bird Nesting and Migration Areas — 2

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands

Shore type

Artificial Fill Area	A
Erodible High Bluff, 30 ft. or higher	HB$_E$
Non-Erodible High Bluff, 30 ft. or higher	HB$_N$
Erodible Low Bluff, less than 30 ft. high	LB$_E$
Non-Erodible Low Bluff, less than 30 ft. high	LB$_N$
High Sand Dune, 30 ft. or higher	HD
Low Sand Dune, less than 30 ft. high	LD
Erodible Low Plain	P$_E$
Non-Erodible Low Plain	P$_N$
Wetlands	W

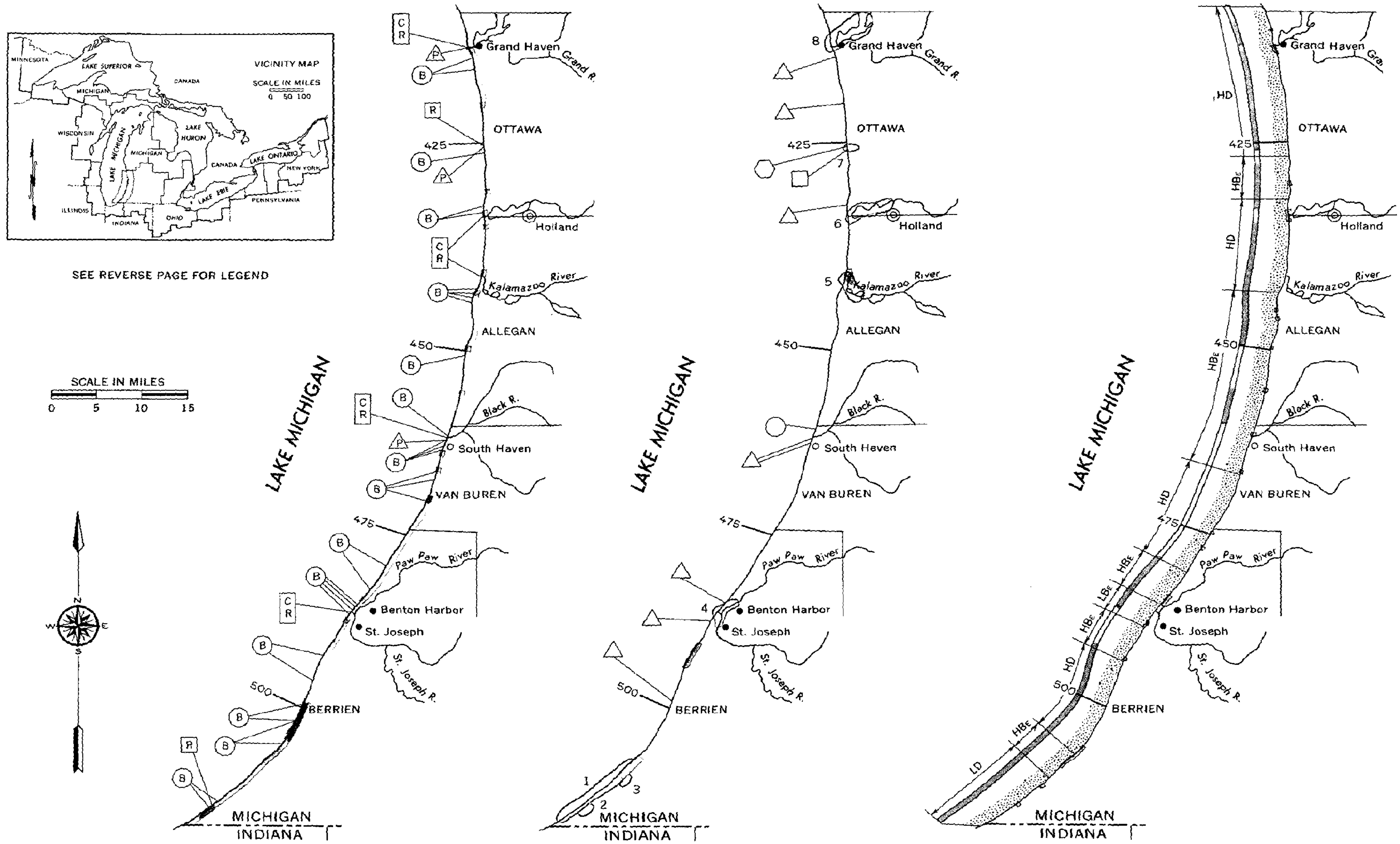
Combinations Shown As:	Example
Lakeward/Landward	W/P$_E$
Upper Bluff Material / Lower Bluff Material	HB$_E$ / HB$_N$

Beach Material

- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems — S



SHORELAND USES.

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES.

SHORELANDS OF THE GREAT LAKES, BERRIEN, VAN BUREN, ALLEGAN, OTTAWA COUNTIES

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches — B
- Commercial Deep Draft Harbors — C
- Recreational Harbors — R
- Commercial Deep Draft and Recreational Harbors — C R
- Electric Power Stations — P

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

Critical Bird Nesting and Migration Areas — 2

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands

Shore type

- Artificial Fill Area — A
- Erodible High Bluff, 30 ft. or higher — HBE
- Non-Erodible High Bluff, 30 ft. or higher — HBN
- Erodible Low Bluff, less than 30 ft. high — LBE
- Non-Erodible Low Bluff, less than 30 ft. high — LBN
- High Sand Dune, 30 ft. or higher — HD
- Low Sand Dune, less than 30 ft. high — LD
- Erodible Low Plain — PE
- Non-Erodible Low Plain — PN
- Wetlands — W

Combinations Shown As: Example

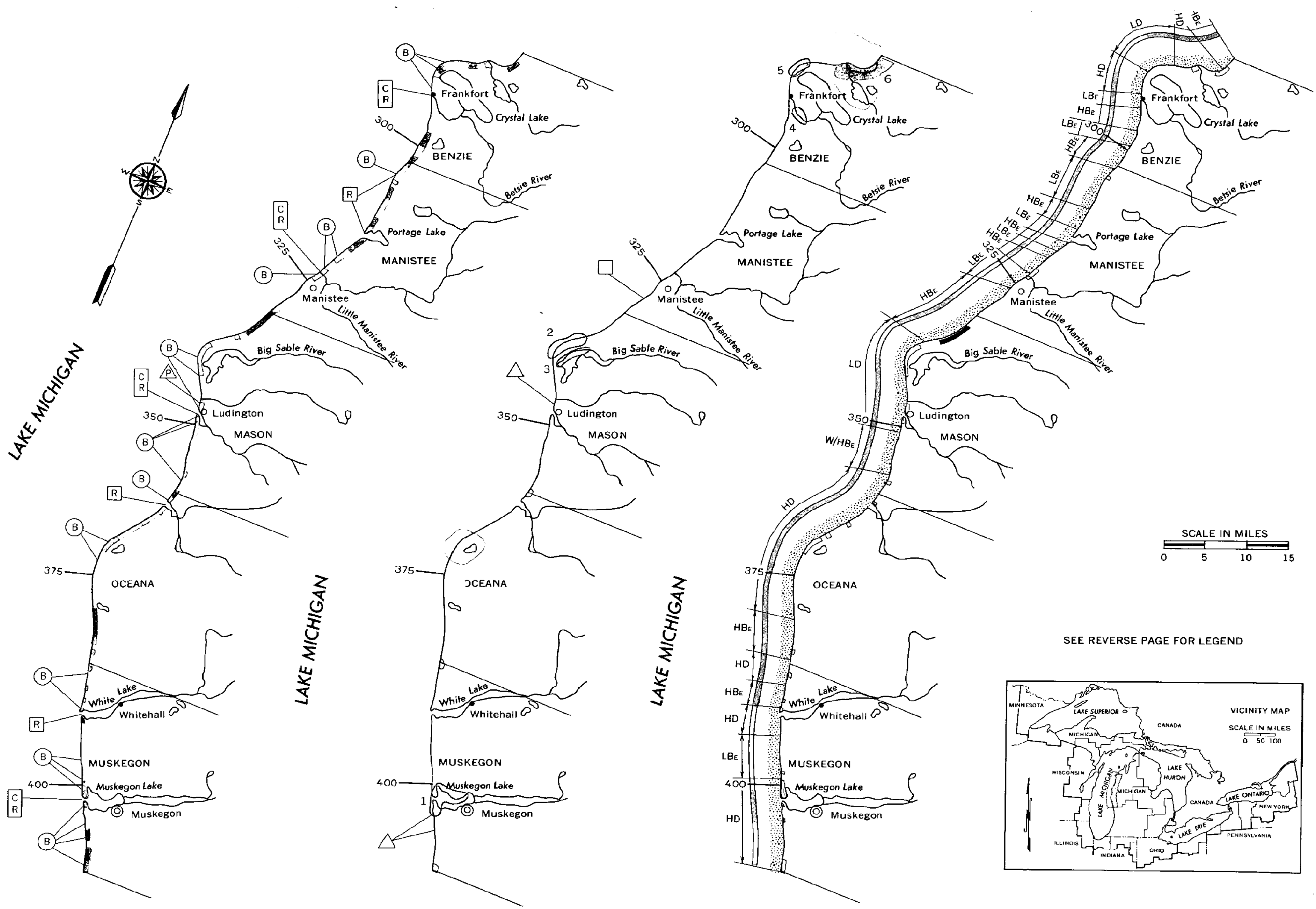
- Lakeward/Landward — W/PE
- Upper Bluff Material / Lower Bluff Material — HBE / HBN

Beach Material

- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems — S



SHORELAND USES.

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES.

SHORELANDS OF THE GREAT LAKES, BENZIE, MANISTEE, MASON, OCEANA, MUSKEGON COUNTIES

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches — B
- Commercial Deep Draft Harbors — C
- Recreational Harbors — R
- Commercial Deep Draft and Recreational Harbors — C R
- Electric Power Stations — P

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

Critical Bird Nesting and Migration Areas — 2

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands

Shore type

- Artificial Fill Area — A
- Erodible High Bluff, 30 ft. or higher — HB_E
- Non-Erodible High Bluff, 30 ft. or higher — HB_N
- Erodible Low Bluff, less than 30 ft. high — LB_E
- Non-Erodible Low Bluff, less than 30 ft. high — LB_N
- High Sand Dune, 30 ft. or higher — HD
- Low Sand Dune, less than 30 ft. high — LD
- Erodible Low Plain — P_E
- Non-Erodible Low Plain — P_N
- Wetlands — W

Combinations Shown As: Example

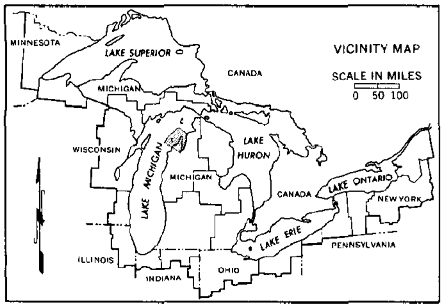
- Lakeward/Landward — W/P_E
- $\frac{\text{Upper Bluff Material}}{\text{Lower Bluff Material}}$ — $\frac{HB_E}{HB_N}$

Beach Material

- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems — S



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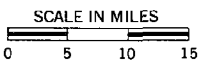
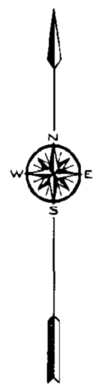
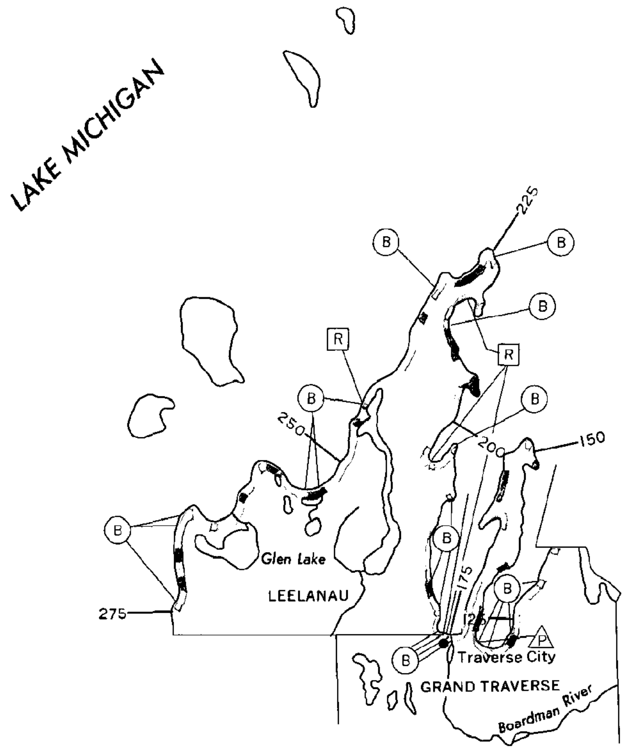
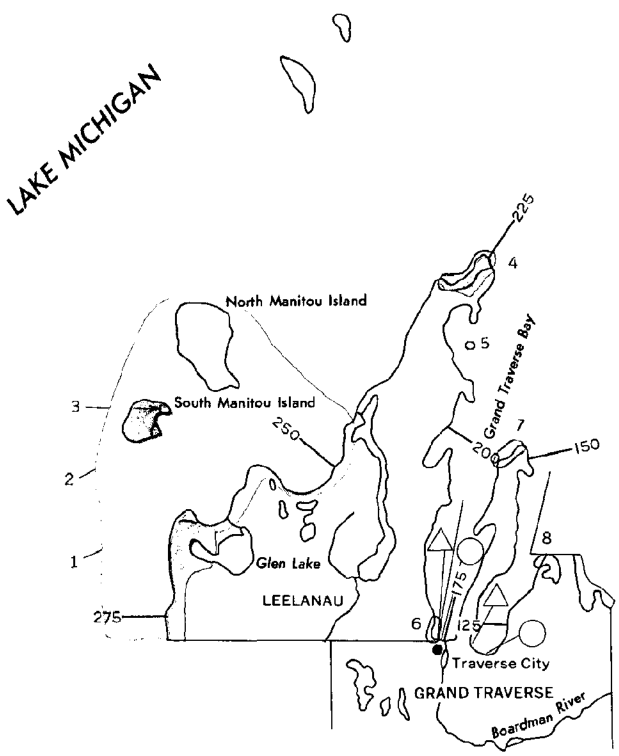


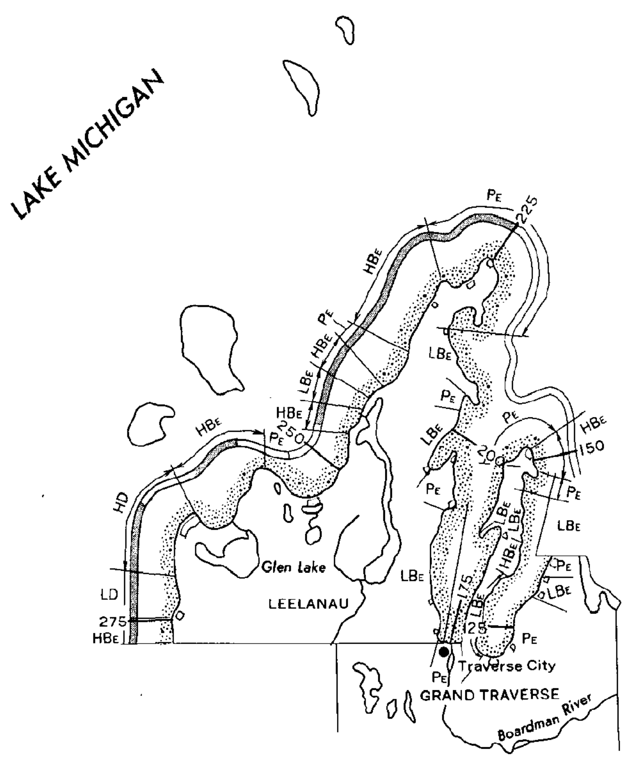




SHORELAND USES.



ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.



PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES.

SHORELANDS OF THE GREAT LAKES, GRAND TRAVERSE, LEELANAU COUNTIES

LEGEND

SHORELAND USES

Commercial, Industrial, Residential and Public Buildings	
Recreational and Urban Open Space	
Agricultural and Undeveloped	
Forest	
Public Beaches	B
Commercial Deep Draft Harbors	C
Recreational Harbors	R
Commercial Deep Draft and Recreational Harbors	C R
Electric Power Stations	P

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

Significant Fish and Wildlife Values	
Unique Ecological or Natural Areas	
Outstanding Shoreland Areas of Possible National Interest	
Potential Recreation Sites	

Waste Water Outfalls and Intakes

Public Outfalls	
Public Intakes	
Private Outfalls	
Private Intakes	

Critical Bird Nesting and Migration Areas	2 O

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

Federal Lands	
Non-Federal Public Lands	
Private Lands	

Shore type

Artificial Fill Area	A
Erodible High Bluff, 30 ft. or higher	HB_E
Non-Erodible High Bluff, 30 ft. or higher	HB_N
Erodible Low Bluff, less than 30 ft. high	LB_E
Non-Erodible Low Bluff, less than 30 ft. high	LB_N
High Sand Dune, 30 ft. or higher	HD
Low Sand Dune, less than 30 ft. high	LD
Erodible Low Plain	P_E
Non-Erodible Low Plain	P_N
Wetlands	W

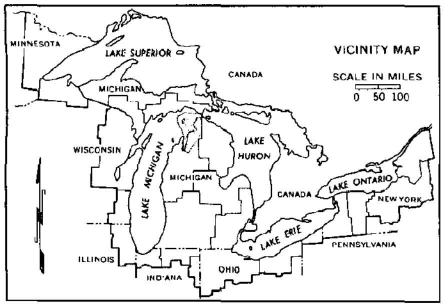
Combinations Shown As:	Example
Lakeward/Landward	W/P_E
$\frac{\text{Upper Bluff Material}}{\text{Lower Bluff Material}}$	$\frac{HB_E}{HB_N}$

Beach Material

Sand and gravel	
Ledge rock	
No Beach	

Problem Identification

Areas subject to erosion generally protected	
Critical erosion areas not protected	
Non-critical erosion areas not protected	
Shoreline subject to lake flooding	
Shoreline not subject to erosion or flooding	
Bluff seepage problems	S



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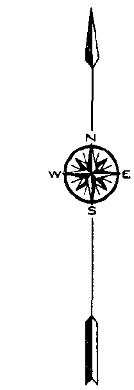
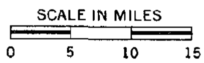
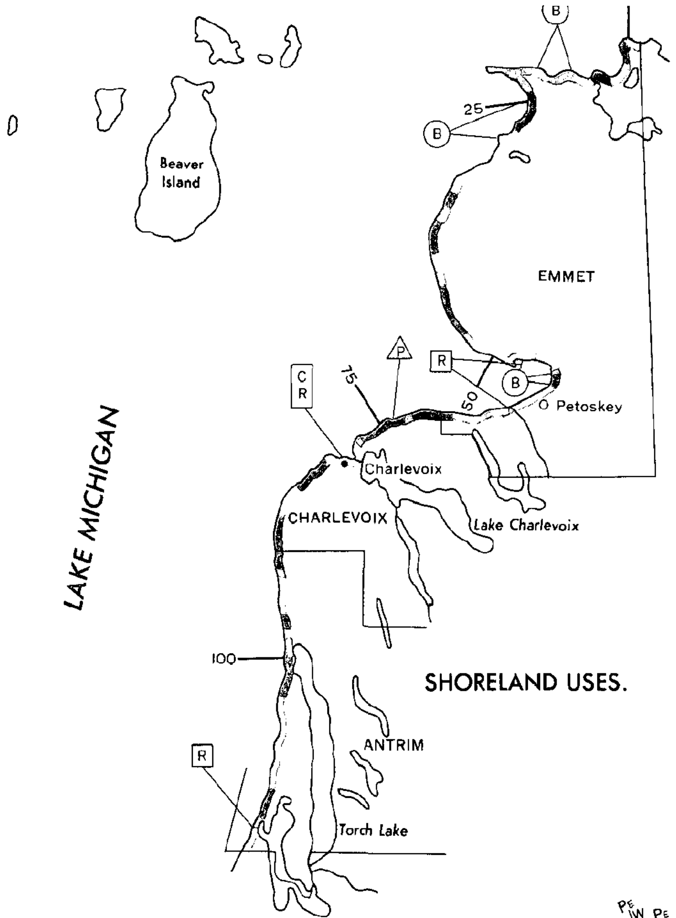
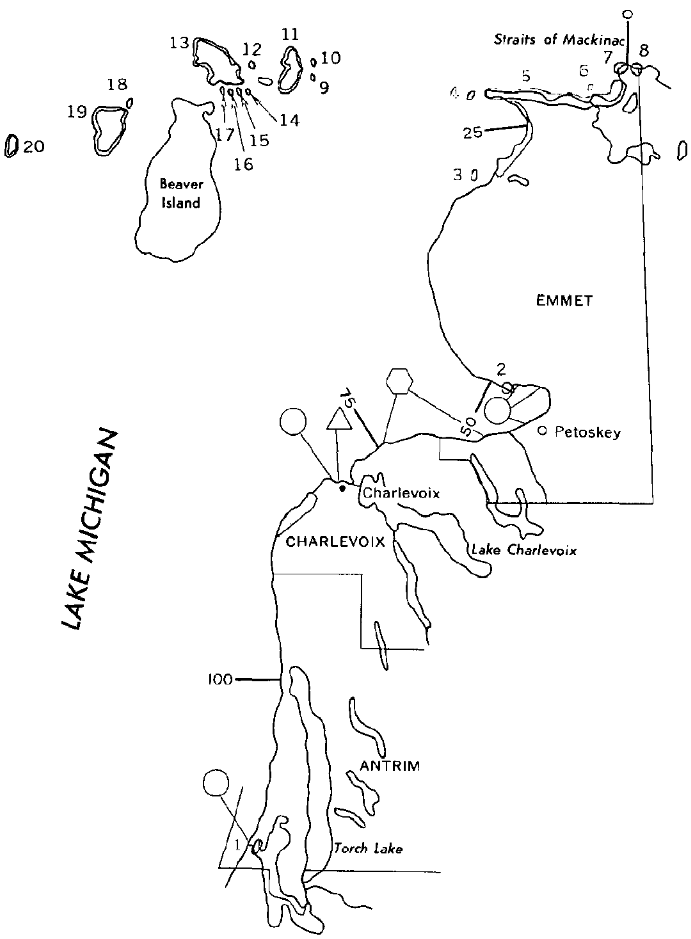


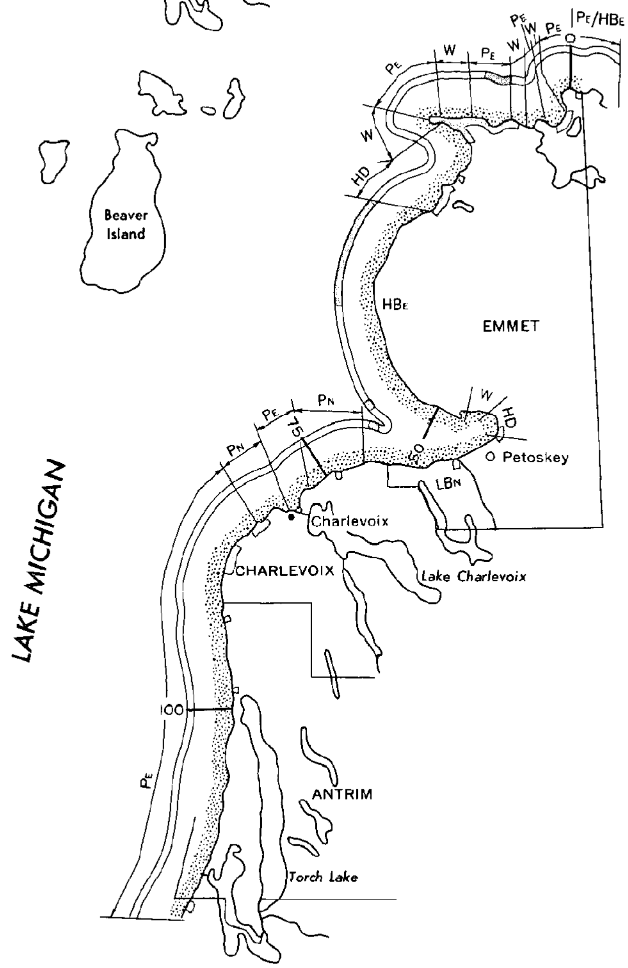




SHORELAND USES.



ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.



PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES.

SHORELANDS OF THE GREAT LAKES, EMMET, CHARLEVOIX, ANTRIM COUNTIES

LEGEND

SHORELAND USES

Commercial, Industrial, Residential and Public Buildings	▭
Recreational and Urban Open Space	▭
Agricultural and Undeveloped	▭
Forest	■
Public Beaches	(B)
Commercial Deep Draft Harbors	[C]
Recreational Harbors	[R]
Commercial Deep Draft and Recreational Harbors	[C R]
Electric Power Stations	△P

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

Significant Fish and Wildlife Values	▭
Unique Ecological or Natural Areas	▭
Outstanding Shoreland Areas of Possible National Interest	▭
Potential Recreation Sites	■

Waste Water Outfalls and Intakes

Public Outfalls	○
Public Intakes	□
Private Outfalls	△
Private Intakes	⬡

Critical Bird Nesting and Migration Areas ——— 2 ○

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

Federal Lands	■
Non-Federal Public Lands	▭
Private Lands	▭

Shore type

Artificial Fill Area	A
Erodible High Bluff, 30 ft. or higher	HB_E
Non-Erodible High Bluff, 30 ft. or higher	HB_N
Erodible Low Bluff, less than 30 ft. high	LB_E
Non-Erodible Low Bluff, less than 30 ft. high	LB_N
High Sand Dune, 30 ft. or higher	HD
Low Sand Dune, less than 30 ft. high	LD
Erodible Low Plain	P_E
Non-Erodible Low Plain	P_N
Wetlands	W

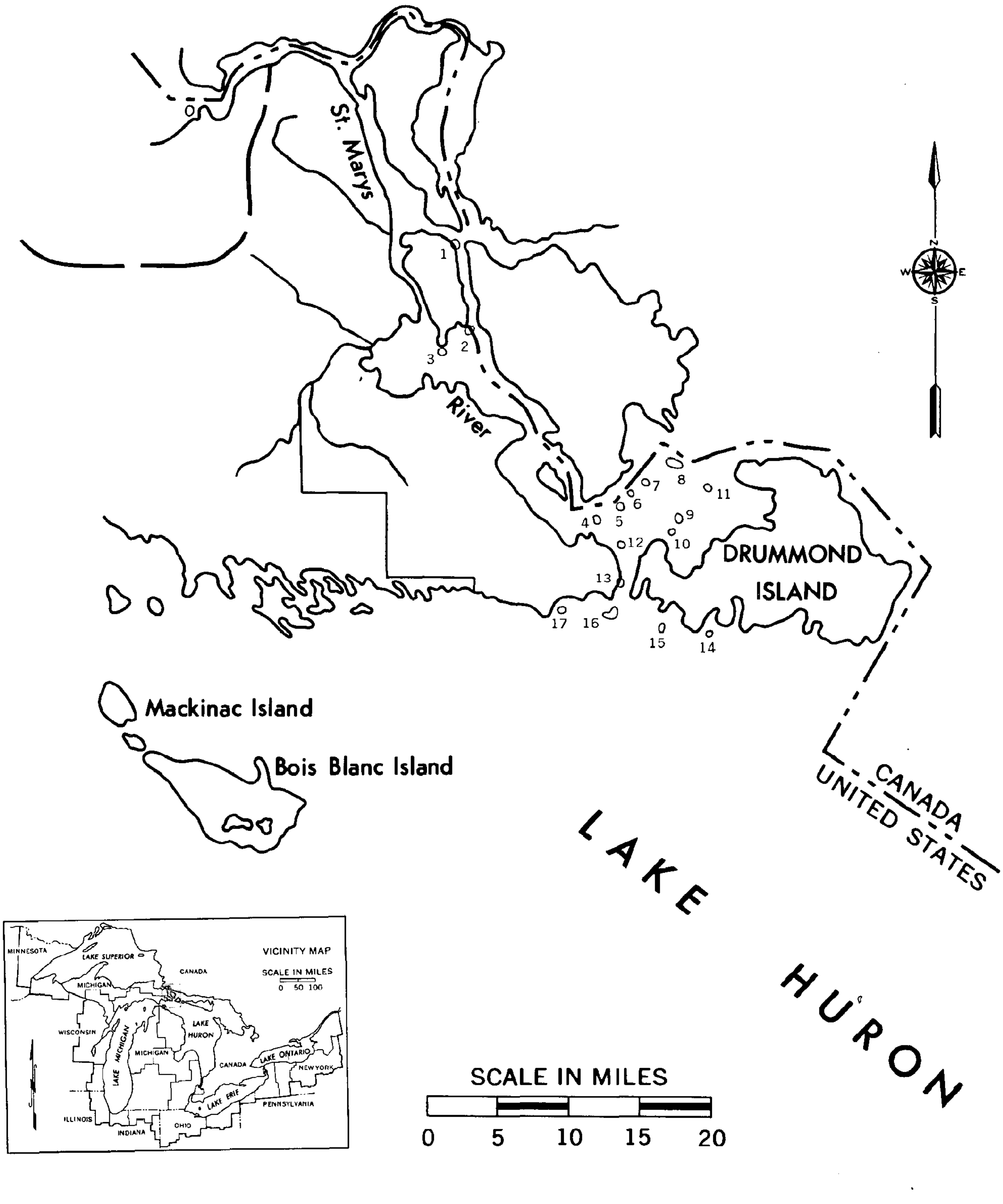
Combinations Shown As:	Example
Lakeward/Landward	W/P_E
$\frac{\text{Upper Bluff Material}}{\text{Lower Bluff Material}}$	$\frac{HB_E}{HB_N}$

Beach Material

Sand and gravel	
Ledge rock	
No Beach	▭

Problem Identification

Areas subject to erosion generally protected	
Critical erosion areas not protected	
Non-critical erosion areas not protected	
Shoreline subject to lake flooding	
Shoreline not subject to erosion or flooding	
Bluff seepage problems	△S



SHORELANDS OF ST. MARYS RIVER

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches — B
- Commercial Deep Draft Harbors — C
- Recreational Harbors — R
- Commercial Deep Draft and Recreational Harbors — C R
- Electric Power Stations — P

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

Critical Bird Nesting and Migration Areas — 2

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands

Shore type

Artificial Fill Area	A
Erodible High Bluff, 30 ft. or higher	HB_E
Non-Erodible High Bluff, 30 ft. or higher	HB_N
Erodible Low Bluff, less than 30 ft. high	LB_E
Non-Erodible Low Bluff, less than 30 ft. high	LB_N
High Sand Dune, 30 ft. or higher	HD
Low Sand Dune, less than 30 ft. high	LD
Erodible Low Plain	P_E
Non-Erodible Low Plain	P_N
Wetlands	W

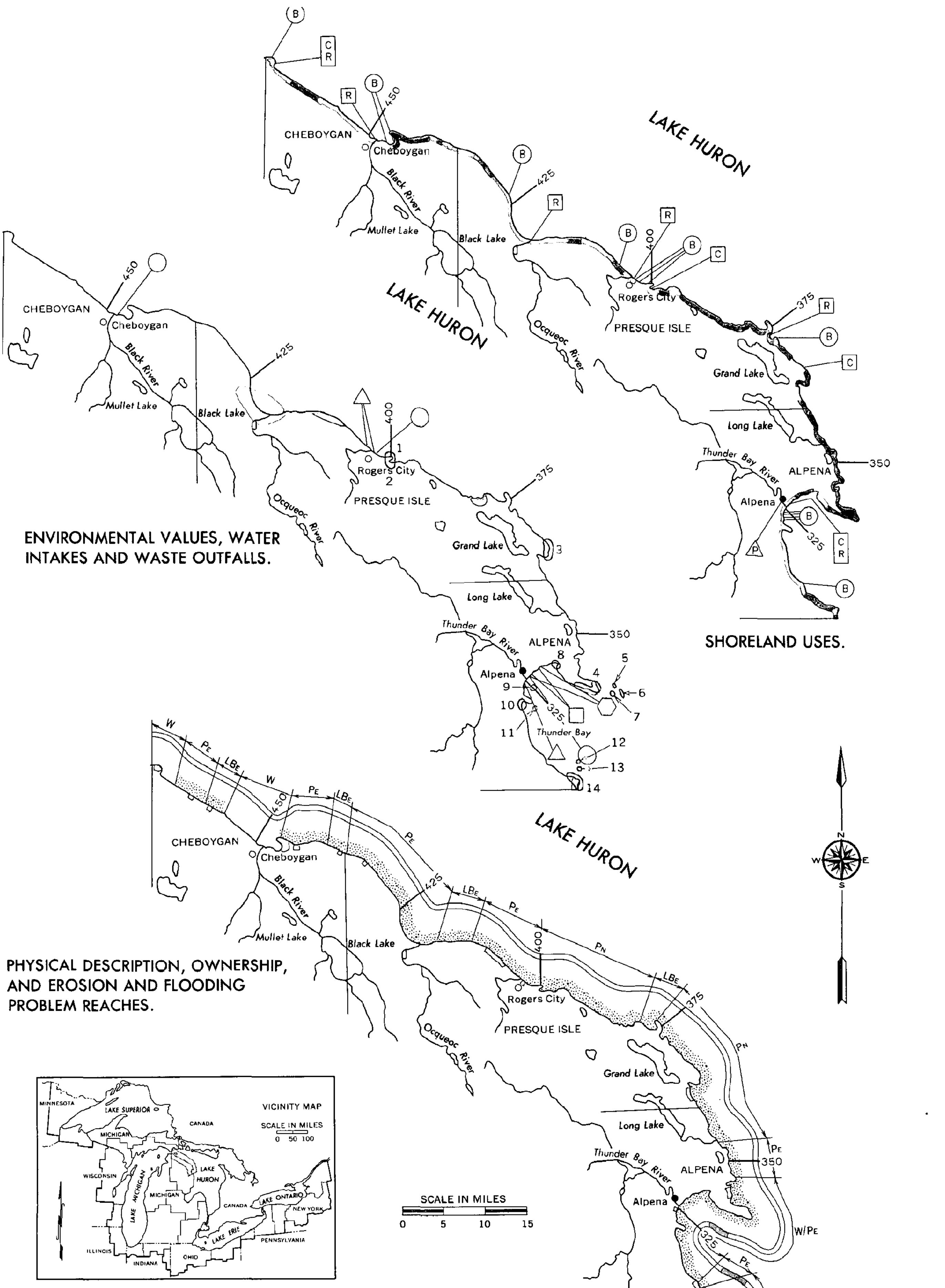
Combinations Shown As:	Example
Lakeward/Landward	W/P_E
$\frac{\text{Upper Bluff Material}}{\text{Lower Bluff Material}}$	$\frac{HB_E}{HB_N}$

Beach Material

- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems — S



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SHORELANDS OF THE GREAT LAKES, ALPENA, PRESQUE ISLE, CHEBOYGAN COUNTIES

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches — B
- Commercial Deep Draft Harbors — C
- Recreational Harbors — R
- Commercial Deep Draft and Recreational Harbors — C R
- Electric Power Stations — P

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites
- Waste Water Outfalls and Intakes
  - Public Outfalls
  - Public Intakes
  - Private Outfalls
  - Private Intakes

Critical Bird Nesting and Migration Areas — 2

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands

Shore type

Artificial Fill Area	A
Erodible High Bluff, 30 ft. or higher	HB_E
Non-Erodible High Bluff, 30 ft. or higher	HB_N
Erodible Low Bluff, less than 30 ft. high	LB_E
Non-Erodible Low Bluff, less than 30 ft. high	LB_N
High Sand Dune, 30 ft. or higher	HD
Low Sand Dune, less than 30 ft. high	LD
Erodible Low Plain	P_E
Non-Erodible Low Plain	P_N
Wetlands	W

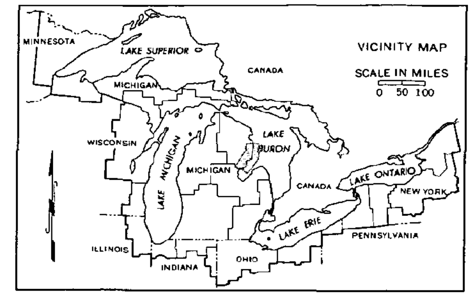
Combinations Shown As:	Example
Lakeward/Landward	W/P_E
$\frac{\text{Upper Bluff Material}}{\text{Lower Bluff Material}}$	$\frac{HB_E}{HB_N}$

Beach Material

- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems — S



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SCALE IN MILES

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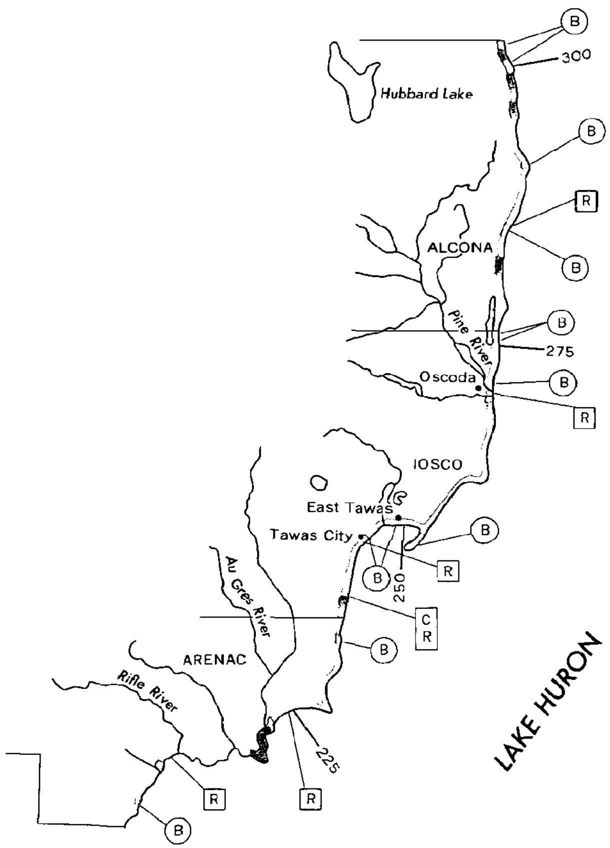
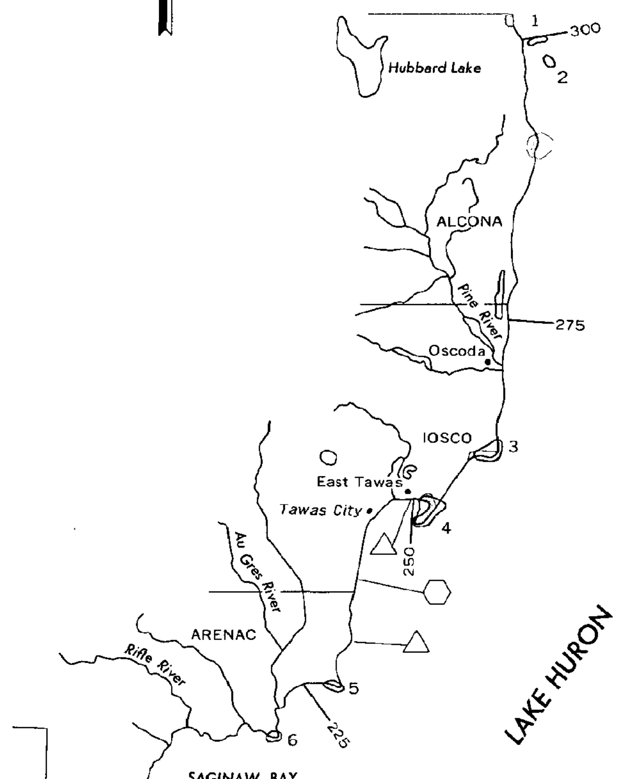
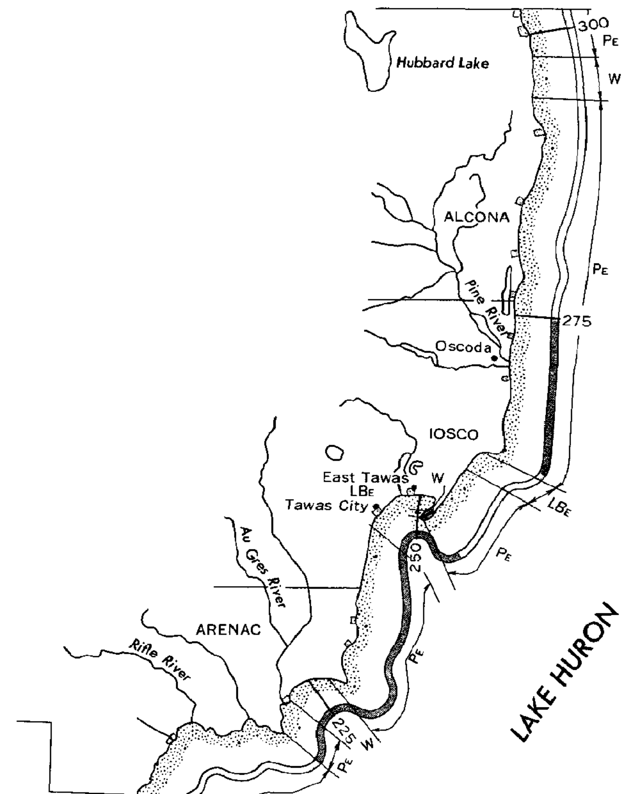


SHORELAND USES.



ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.



PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES.

SHORELANDS OF THE GREAT LAKES, ARENAC, IOSCO, ALCONA COUNTIES

LEGEND

SHORELAND USES

Commercial, Industrial, Residential and Public Buildings	
Recreational and Urban Open Space	
Agricultural and Undeveloped	
Forest	
Public Beaches	B
Commercial Deep Draft Harbors	C
Recreational Harbors	R
Commercial Deep Draft and Recreational Harbors	C R
Electric Power Stations	P

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

Significant Fish and Wildlife Values	
Unique Ecological or Natural Areas	
Outstanding Shoreland Areas of Possible National Interest	
Potential Recreation Sites	

Waste Water Outfalls and Intakes

Public Outfalls	
Public Intakes	
Private Outfalls	
Private Intakes	

Critical Bird Nesting and Migration Areas 2

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

Federal Lands	
Non-Federal Public Lands	
Private Lands	

Shore type

Artificial Fill Area	A
Erodible High Bluff, 30 ft. or higher	HB_E
Non-Erodible High Bluff, 30 ft. or higher	HB_N
Erodible Low Bluff, less than 30 ft. high	LB_E
Non-Erodible Low Bluff, less than 30 ft. high	LB_N
High Sand Dune, 30 ft. or higher	HD
Low Sand Dune, less than 30 ft. high	LD
Erodible Low Plain	P_E
Non-Erodible Low Plain	P_N
Wetlands	W

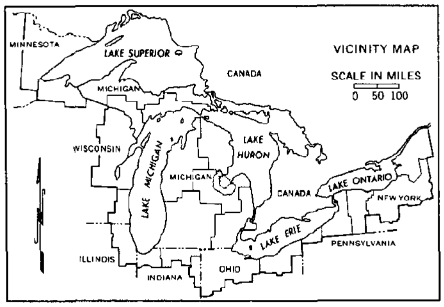
Combinations Shown As:	Example
Lakeward/Landward	W/P_E
$\frac{\text{Upper Bluff Material}}{\text{Lower Bluff Material}}$	$\frac{HB_E}{HB_N}$

Beach Material

Sand and gravel	
Ledge rock	
No Beach	

Problem Identification

Areas subject to erosion generally protected	
Critical erosion areas not protected	
Non-critical erosion areas not protected	
Shoreline subject to lake flooding	
Shoreline not subject to erosion or flooding	
Bluff seepage problems	S



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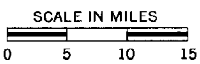
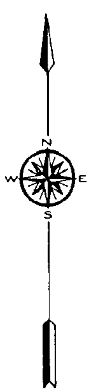
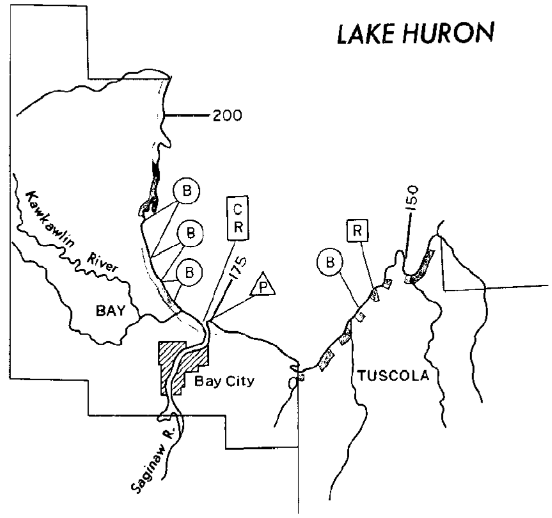
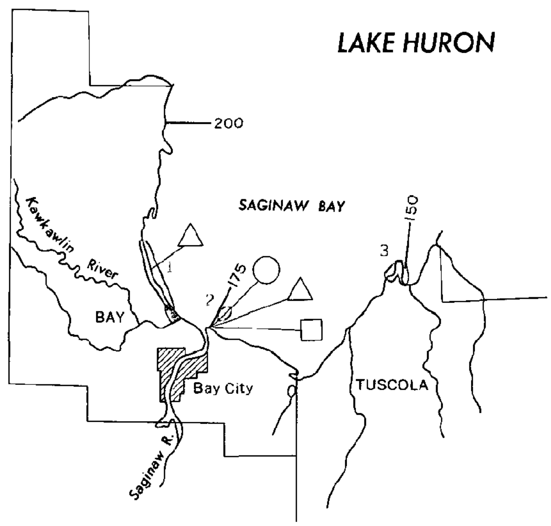


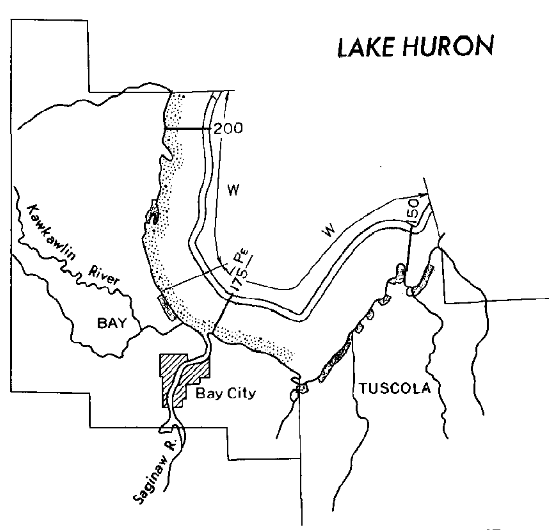




SHORELAND USES.



ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.



PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES.

SHORELANDS OF THE GREAT LAKES, TUSCOLA, BAY COUNTIES

LEGEND

SHORELAND USES

Commercial, Industrial, Residential and Public Buildings

Recreational and Urban Open Space

Agricultural and Undeveloped

Forest

Public Beaches — (B)

Commercial Deep Draft Harbors — [C]

Recreational Harbors — [R]

Commercial Deep Draft and Recreational Harbors — [C R]

Electric Power Stations — (P in triangle)

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

Significant Fish and Wildlife Values

Unique Ecological or Natural Areas

Outstanding Shoreland Areas of Possible National Interest

Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

Critical Bird Nesting and Migration Areas — 2 O

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

Federal Lands

Non-Federal Public Lands

Private Lands

Shore type

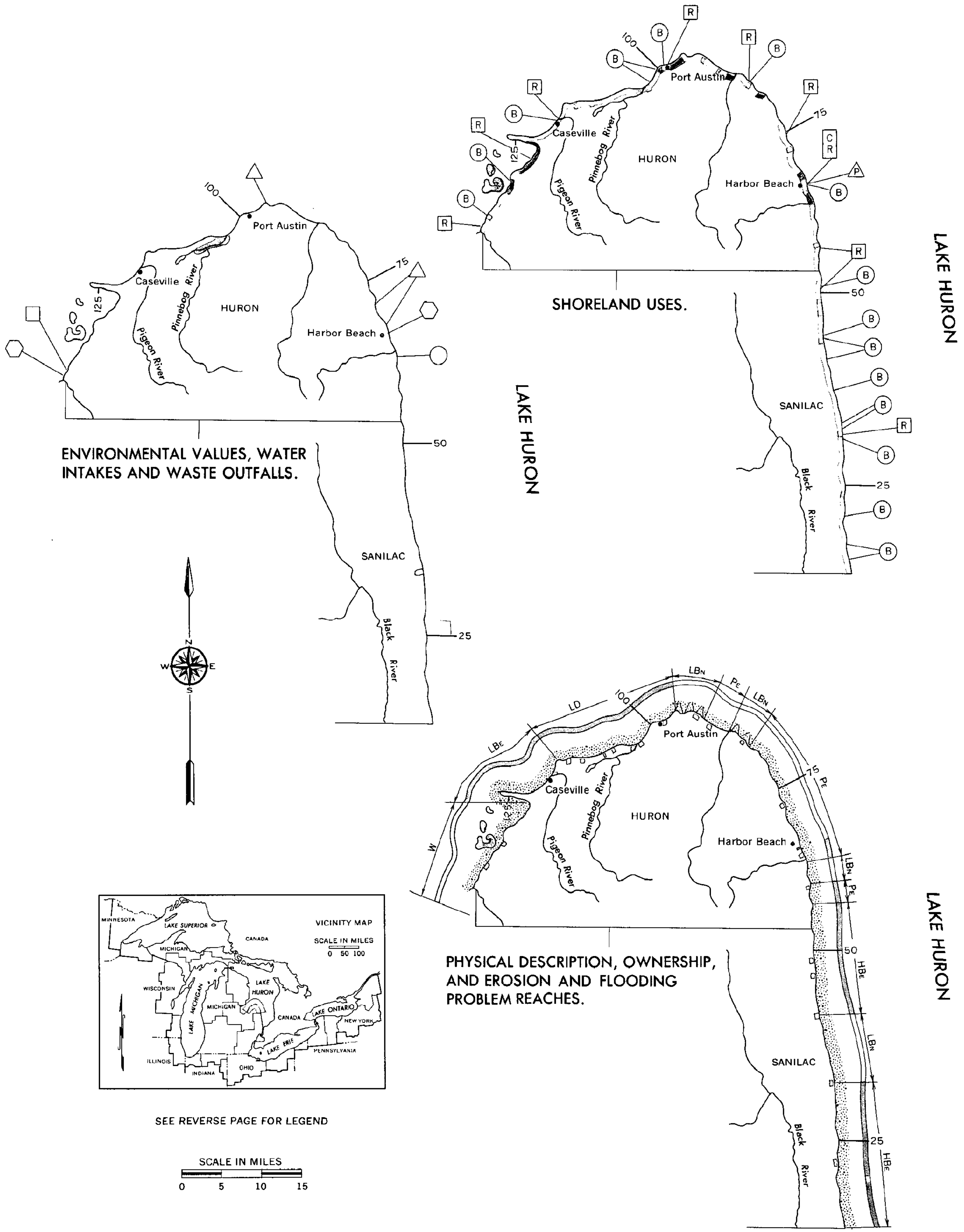
Artificial Fill Area	A
Erodible High Bluff, 30 ft. or higher	HBE
Non-Erodible High Bluff, 30 ft. or higher	HBN
Erodible Low Bluff, less than 30 ft. high	LBE
Non-Erodible Low Bluff, less than 30 ft. high	LBN
High Sand Dune, 30 ft. or higher	HD
Low Sand Dune, less than 30 ft. high	LD
Erodible Low Plain	PE
Non-Erodible Low Plain	PN
Wetlands	W
Combinations Shown As:	Example
Lakeward/Landward	W/PE
Upper Bluff Material / Lower Bluff Material	HBE / HBN

Beach Material

- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems — (S in triangle)



SHORELANDS OF THE GREAT LAKES, SANILAC, HURON COUNTIES

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches — B
- Commercial Deep Draft Harbors — C
- Recreational Harbors — R
- Commercial Deep Draft and Recreational Harbors — C R
- Electric Power Stations — P

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

Critical Bird Nesting and Migration Areas — 2

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands

Shore type

- Artificial Fill Area — A
- Erodible High Bluff, 30 ft. or higher — HB_E
- Non-Erodible High Bluff, 30 ft. or higher — HB_N
- Erodible Low Bluff, less than 30 ft. high — LB_E
- Non-Erodible Low Bluff, less than 30 ft. high — LB_N
- High Sand Dune, 30 ft. or higher — HD
- Low Sand Dune, less than 30 ft. high — LD
- Erodible Low Plain — P_E
- Non-Erodible Low Plain — P_N
- Wetlands — W

Combinations Shown As: Example

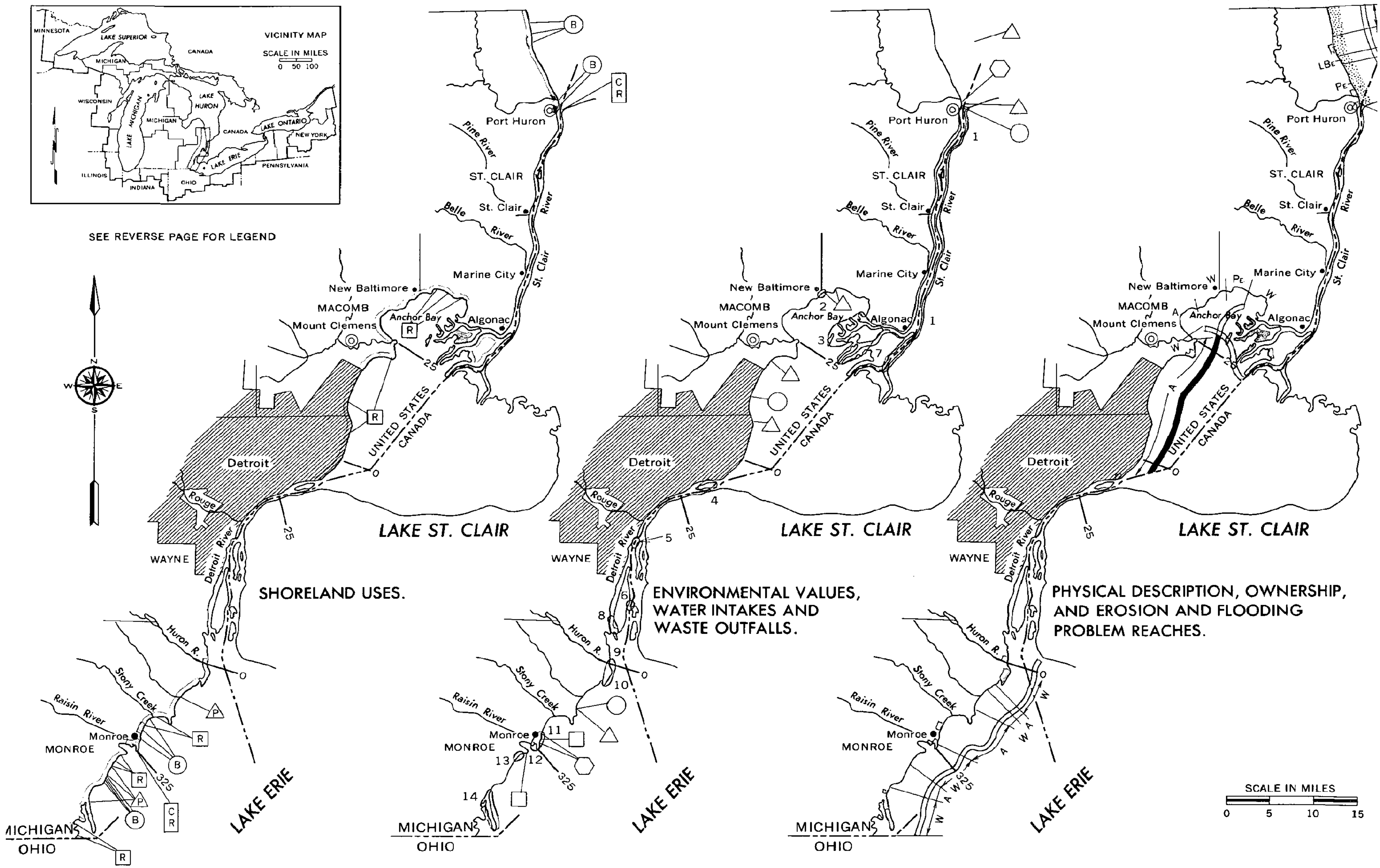
- Lakeward/Landward — W/P_E
- Upper Bluff Material / Lower Bluff Material — $\frac{HB_E}{HB_N}$

Beach Material

- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems — S



SHORELANDS OF THE GREAT LAKES, MONROE, WAYNE, MACOMB, ST. CLAIR COUNTIES

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches — B
- Commercial Deep Draft Harbors — C
- Recreational Harbors — R
- Commercial Deep Draft and Recreational Harbors — C R
- Electric Power Stations — P

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

Critical Bird Nesting and Migration Areas — 2

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands

Shore type

- Artificial Fill Area — A
- Erodible High Bluff, 30 ft. or higher — HB_E
- Non-Erodible High Bluff, 30 ft. or higher — HB_N
- Erodible Low Bluff, less than 30 ft. high — LB_E
- Non-Erodible Low Bluff, less than 30 ft. high — LB_N
- High Sand Dune, 30 ft. or higher — HD
- Low Sand Dune, less than 30 ft. high — LD
- Erodible Low Plain — P_E
- Non-Erodible Low Plain — P_N
- Wetlands — W

Combinations Shown As: Example

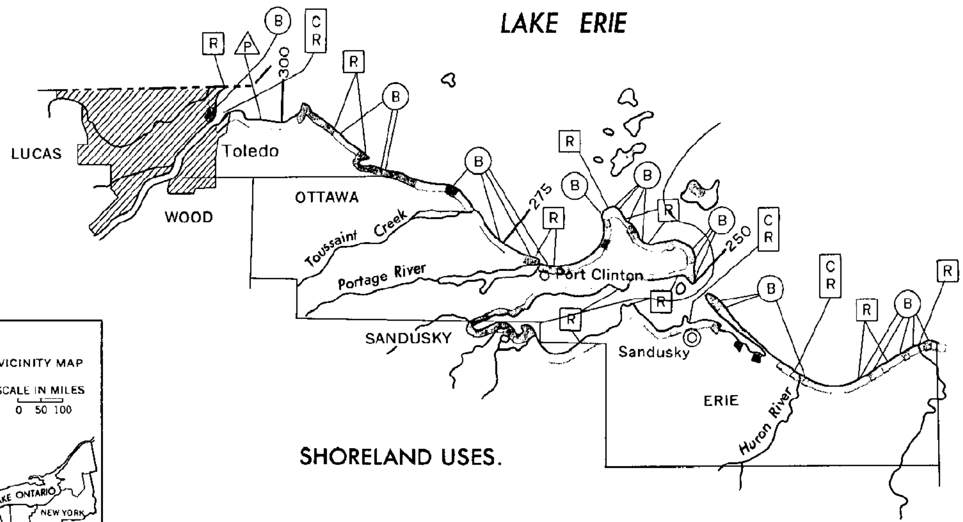
- Lakeward/Landward — W/P_E
- Upper Bluff Material / Lower Bluff Material — $\frac{HB_E}{HB_N}$

Beach Material

- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems — S



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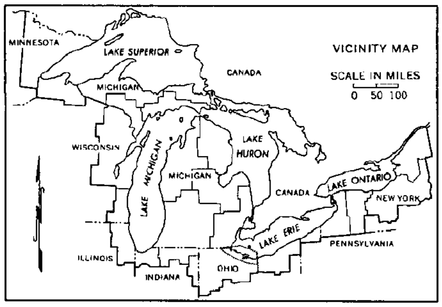

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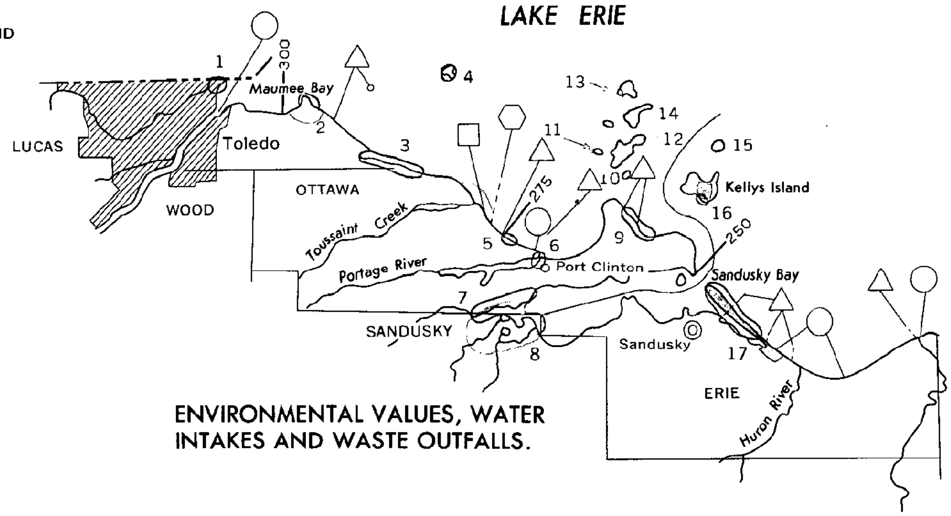
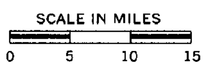
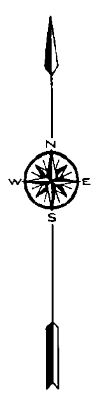
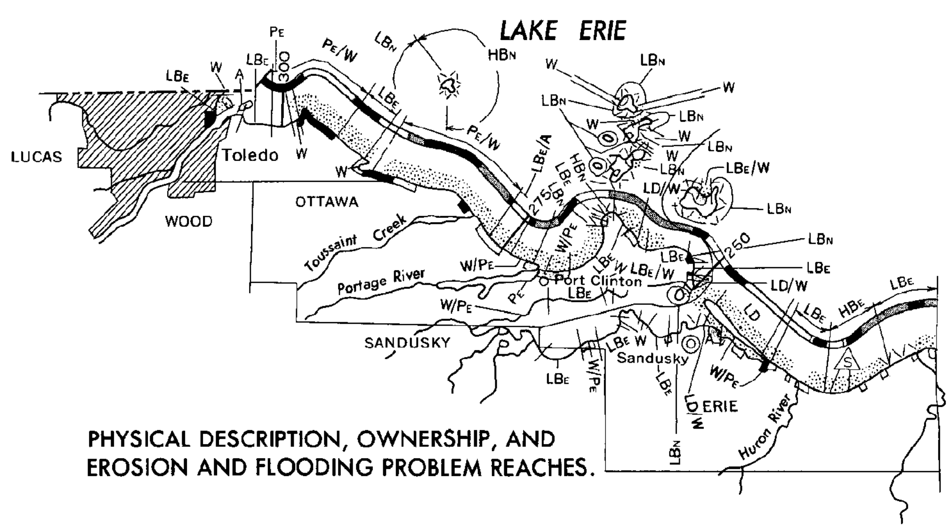




ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.





PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES.

SHORELANDS OF THE GREAT LAKES, ERIE, SANDUSKY, OTTAWA, LUCAS COUNTIES

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches — (B)
- Commercial Deep Draft Harbors — [C]
- Recreational Harbors — [R]
- Commercial Deep Draft and Recreational Harbors — [C R]
- Electric Power Stations — P

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites
- Waste Water Outfalls and Intakes
  - Public Outfalls
  - Public Intakes
  - Private Outfalls
  - Private Intakes

Critical Bird Nesting and Migration Areas — 2

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands

Shore type

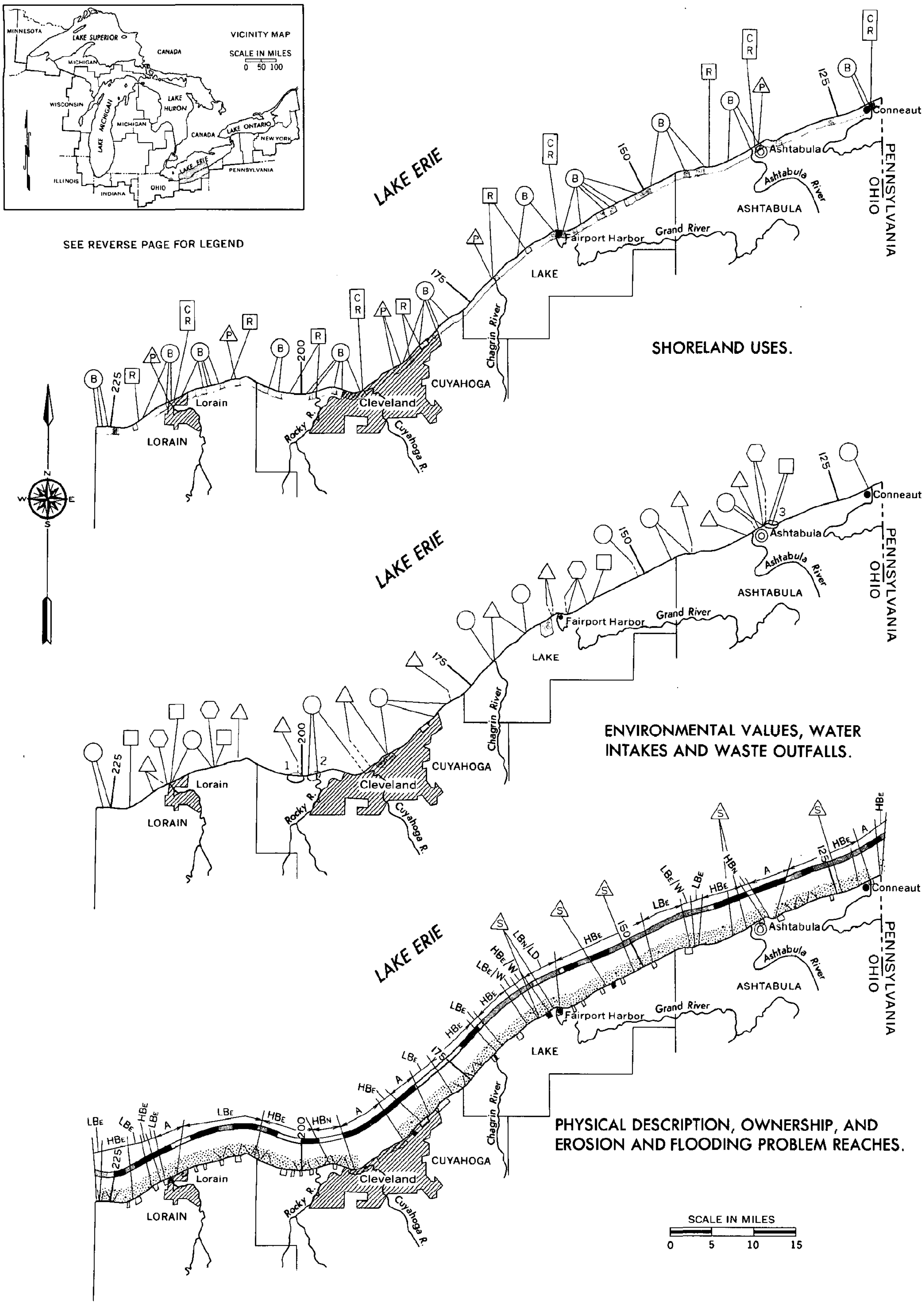
Artificial Fill Area	A
Erodible High Bluff, 30 ft. or higher	HBE
Non-Erodible High Bluff, 30 ft. or higher	HBN
Erodible Low Bluff, less than 30 ft. high	LBE
Non-Erodible Low Bluff, less than 30 ft. high	LBN
High Sand Dune, 30 ft. or higher	HD
Low Sand Dune, less than 30 ft. high	LD
Erodible Low Plain	PE
Non-Erodible Low Plain	PN
Wetlands	W
Combinations Shown As:	Example
Lakeward/Landward	W/PE
Upper Bluff Material / Lower Bluff Material	HBE / HBN

Beach Material

- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems — S



SHORELANDS OF THE GREAT LAKES, ASHTABULA, LAKE, CUYAHOGA, LORAIN COUNTIES

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches — (B)
- Commercial Deep Draft Harbors — C
- Recreational Harbors — R
- Commercial Deep Draft and Recreational Harbors — C R
- Electric Power Stations — P

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

Critical Bird Nesting and Migration Areas — 2

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands

Shore type

- Artificial Fill Area — A
- Erodible High Bluff, 30 ft. or higher — HBE
- Non-Erodible High Bluff, 30 ft. or higher — HBN
- Erodible Low Bluff, less than 30 ft. high — LBE
- Non-Erodible Low Bluff, less than 30 ft. high — LBN
- High Sand Dune, 30 ft. or higher — HD
- Low Sand Dune, less than 30 ft. high — LD
- Erodible Low Plain — PE
- Non-Erodible Low Plain — PN
- Wetlands — W

Combinations Shown As: Example

- Lakeward/Landward — W/PE
- Upper Bluff Material / Lower Bluff Material — HBE / HBN

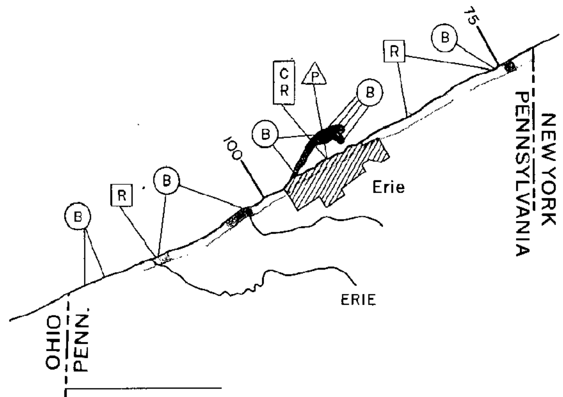
Beach Material

- Sand and gravel
- Ledge rock
- No Beach

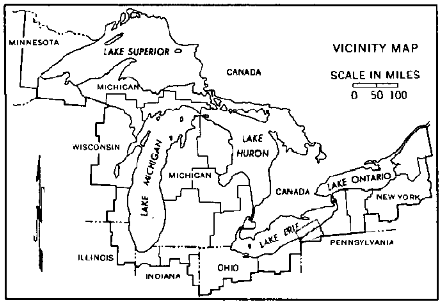
Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems — S

LAKE ERIE



SHORELAND USES.



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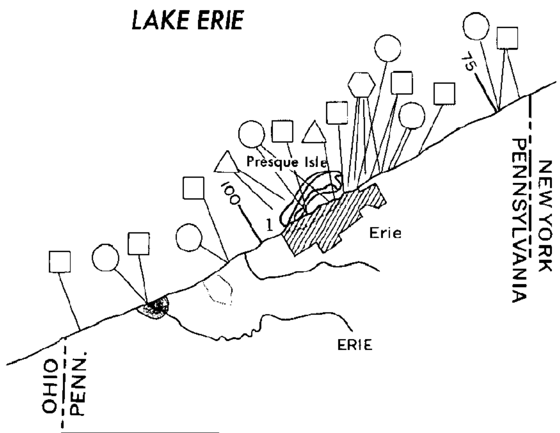
LAKE ERIE



ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.

SCALE IN MILES

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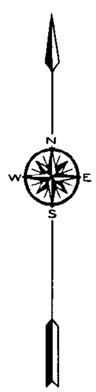
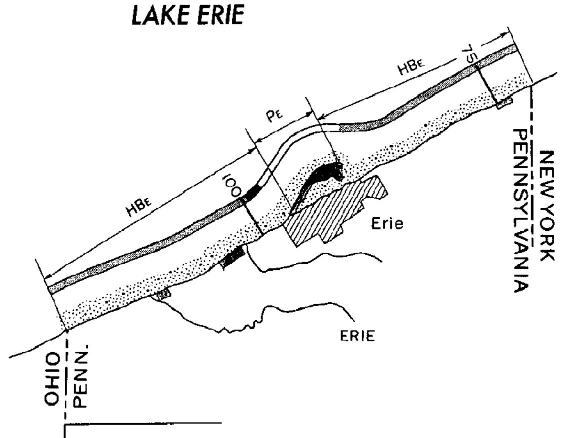


LAKE ERIE



PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES.

SHORELANDS OF THE GREAT LAKES, ERIE COUNTY

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches — B
- Commercial Deep Draft Harbors — C
- Recreational Harbors — R
- Commercial Deep Draft and Recreational Harbors — C R
- Electric Power Stations — P

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

Critical Bird Nesting and Migration Areas — 2

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands

Shore type

Artificial Fill Area	A
Erodible High Bluff, 30 ft. or higher	HB_E
Non-Erodible High Bluff, 30 ft. or higher	HB_N
Erodible Low Bluff, less than 30 ft. high	LB_E
Non-Erodible Low Bluff, less than 30 ft. high	LB_N
High Sand Dune, 30 ft. or higher	HD
Low Sand Dune, less than 30 ft. high	LD
Erodible Low Plain	P_E
Non-Erodible Low Plain	P_N
Wetlands	W

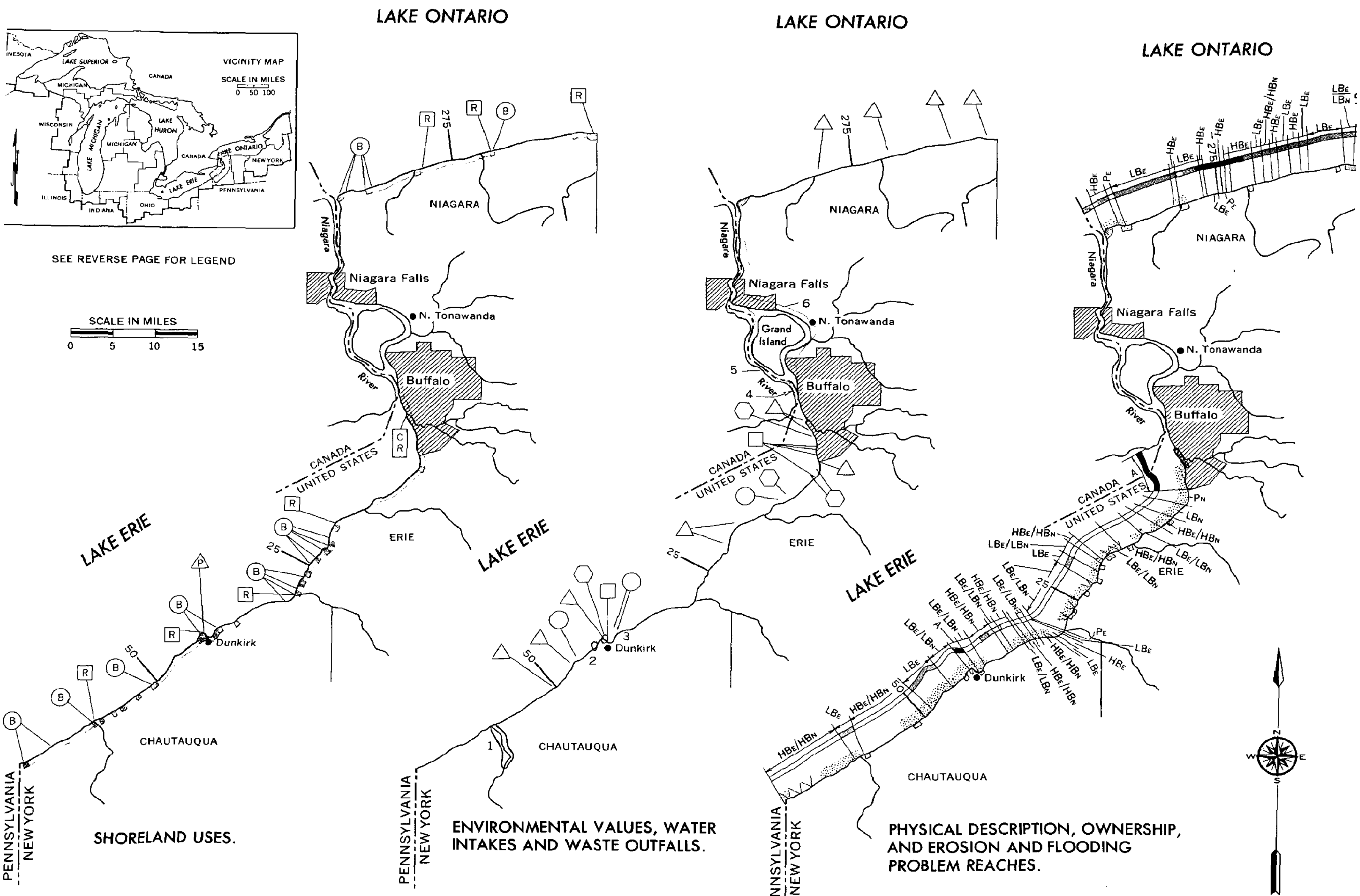
Combinations Shown As:	Example
Lakeward/Landward	W/P_E
Upper Bluff Material / Lower Bluff Material	$\frac{HB_E}{HB_N}$

Beach Material

- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems — S



SHORELANDS OF THE GREAT LAKES, NIAGARA, ERIE, CHAUTAQUA COUNTIES

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches — B
- Commercial Deep Draft Harbors — C
- Recreational Harbors — R
- Commercial Deep Draft and Recreational Harbors — C R
- Electric Power Stations — P

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National *Interest*
- Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

Critical Bird Nesting and Migration Areas — 2

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands

Shore type

Artificial Fill Area	A
Erodible High Bluff, 30 ft. or higher	HB_E
Non-Erodible High Bluff, 30 ft. or higher	HB_N
Erodible Low Bluff, less than 30 ft. high	LB_E
Non-Erodible Low Bluff, less than 30 ft. high	LB_N
High Sand Dune, 30 ft. or higher	HD
Low Sand Dune, less than 30 ft. high	LD
Erodible Low Plain	P_E
Non-Erodible Low Plain	P_N
Wetlands	W

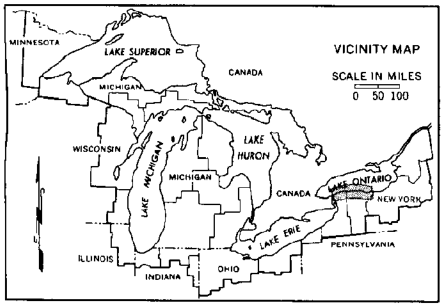
Combinations Shown As:	Example
Lakeward/Landward	W/P_E
$\frac{\text{Upper Bluff Material}}{\text{Lower Bluff Material}}$	$\frac{HB_E}{HB_N}$

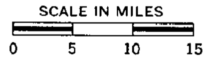
Beach Material

- Sand and gravel
- *Ledge rock*
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- *Shoreline subject to lake* flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems — S





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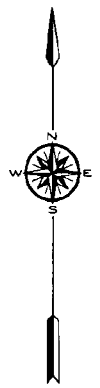
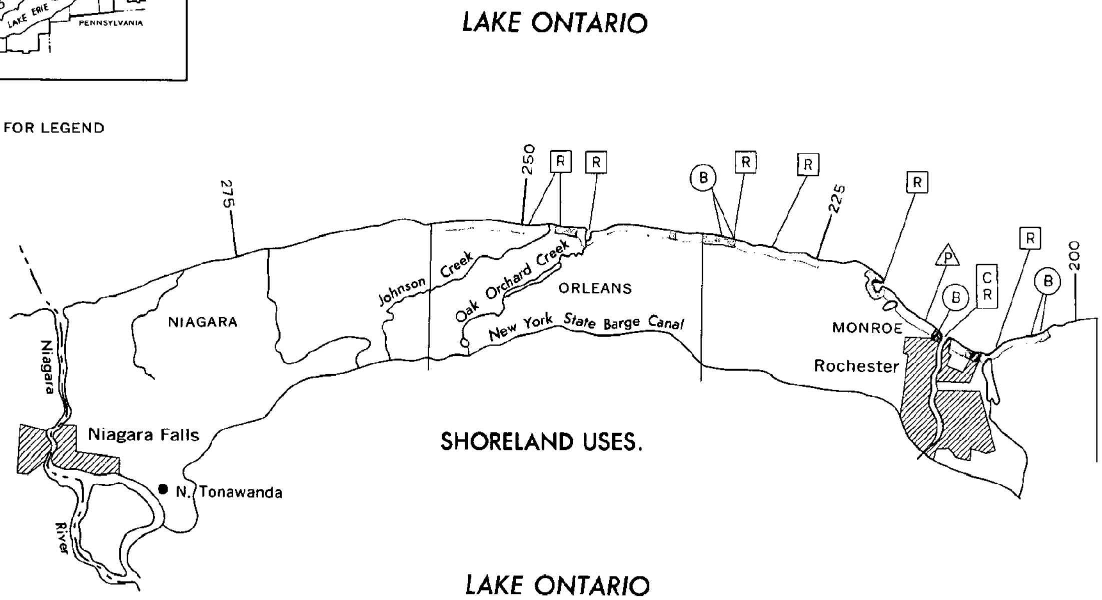
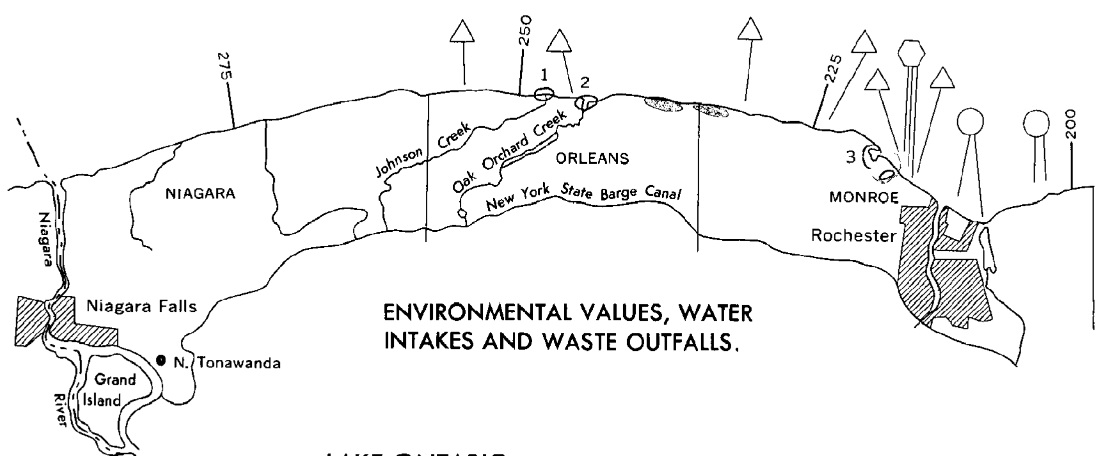
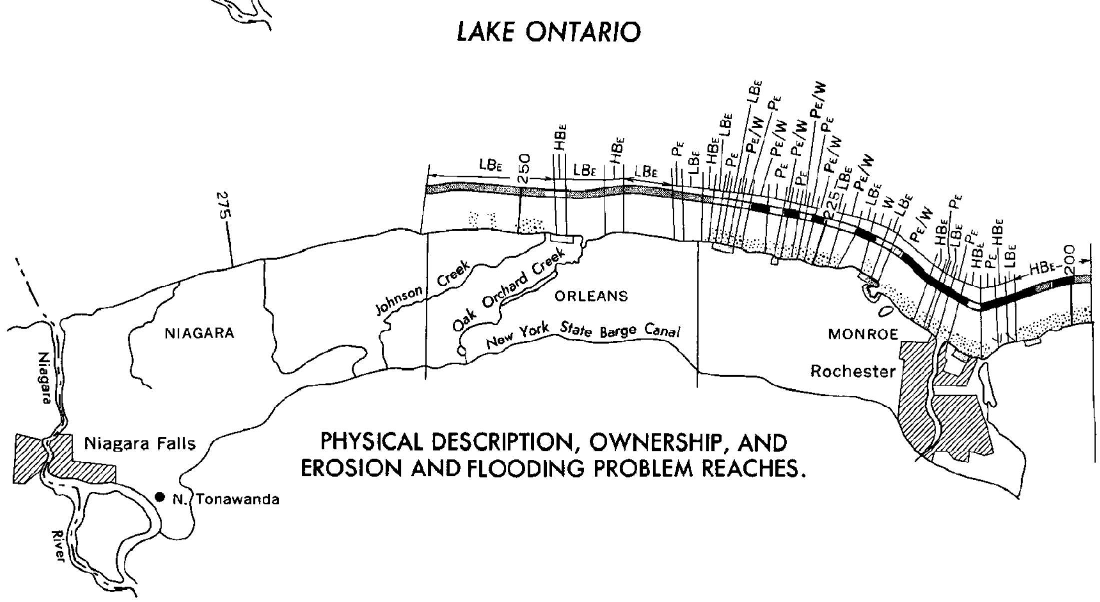








SHORELANDS OF THE GREAT LAKES MONROE ORLEANS COUNTIES

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches — B
- Commercial Deep Draft Harbors — C
- Recreational Harbors — R
- Commercial Deep Draft and Recreational Harbors — C R
- Electric Power Stations — P

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

Critical Bird Nesting and Migration Areas — 2

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands

Shore type

- Artificial Fill Area — A
- Erodible High Bluff, 30 ft. or higher — HB_E
- Non-Erodible High Bluff, 30 ft. or higher — HB_N
- Erodible Low Bluff, less than 30 ft. high — LB_E
- Non-Erodible Low Bluff, less than 30 ft. high — LB_N
- High Sand Dune, 30 ft. or higher — HD
- Low Sand Dune, less than 30 ft. high — LD
- Erodible Low Plain — P_E
- Non-Erodible Low Plain — P_N
- Wetlands — W

Combinations Shown As: — Example

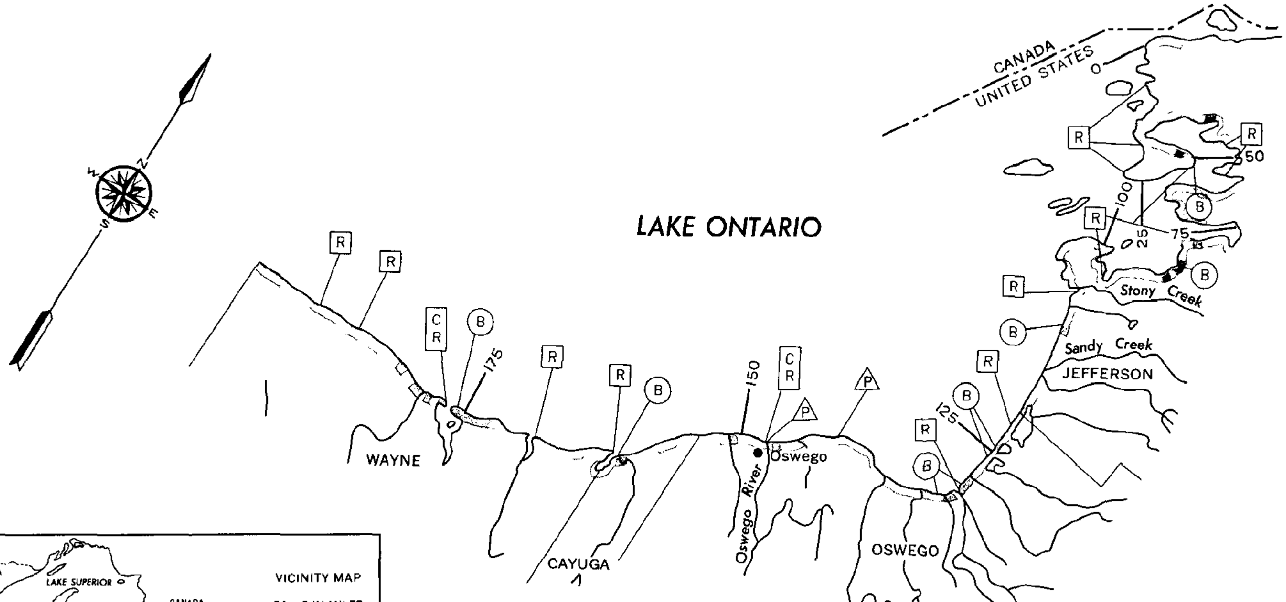
- Lakeward/Landward — W/P_E
- Upper Bluff Material / Lower Bluff Material — $\frac{HB_E}{HB_N}$

Beach Material

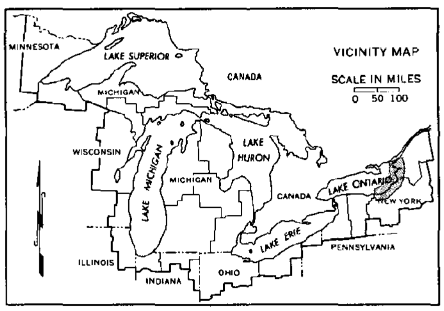
- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems — S



SHORELAND USES.



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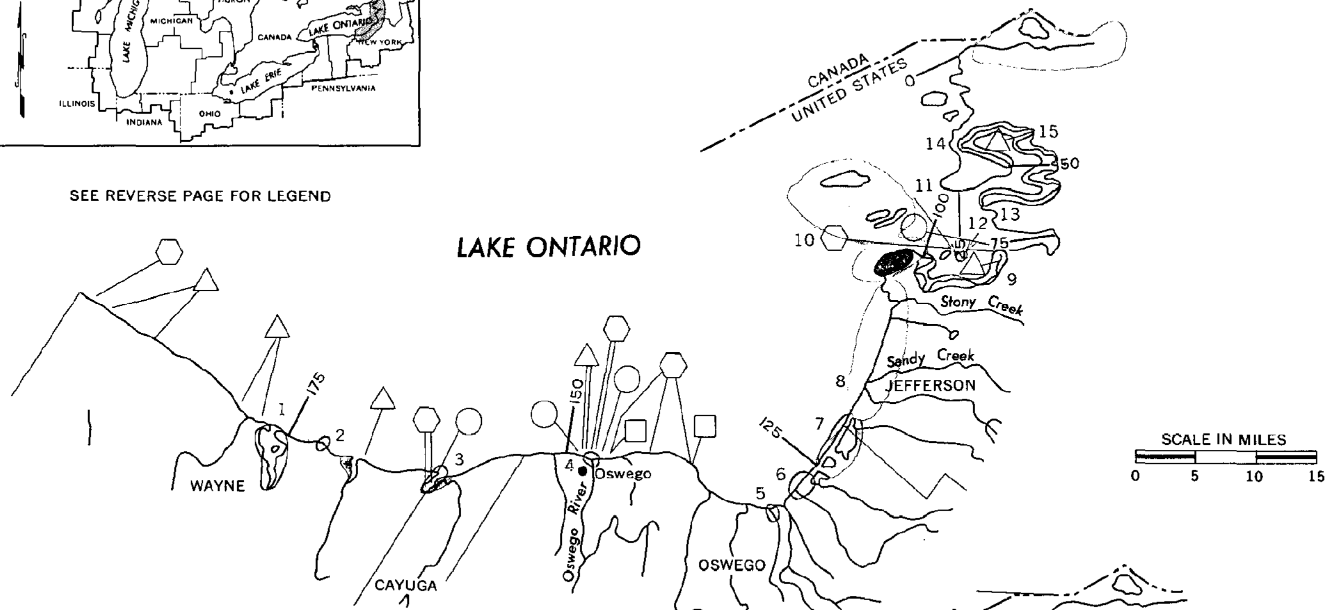
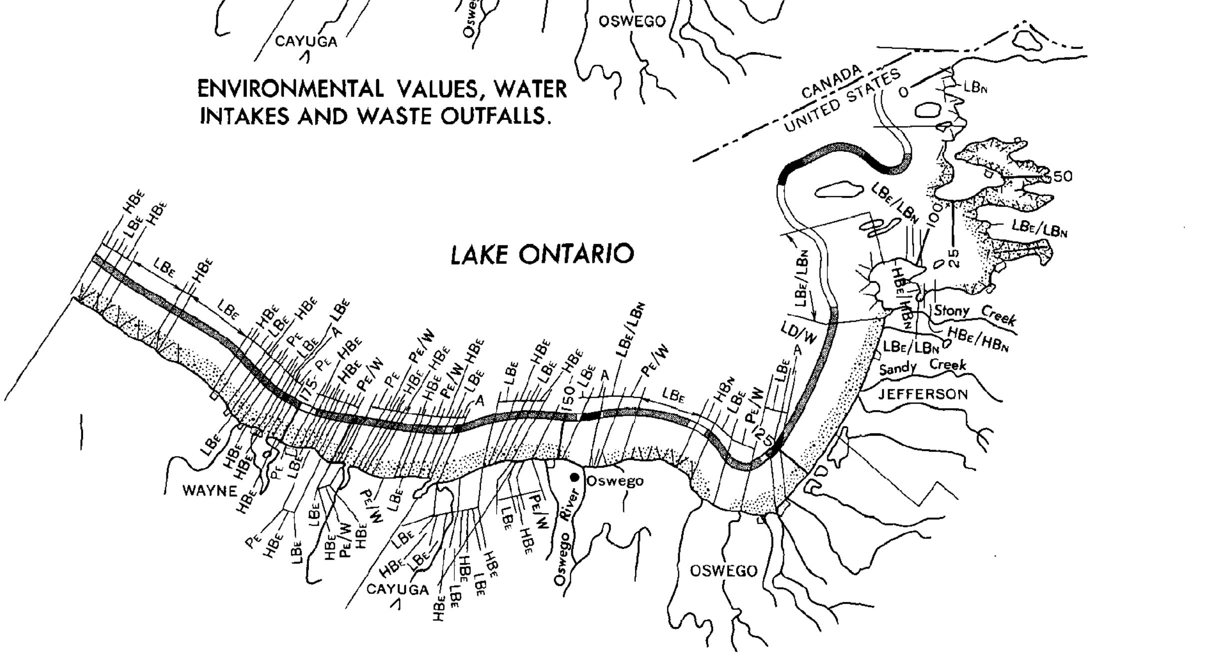


ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.



PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES.

SHORELANDS OF THE GREAT LAKES, CAPE VINCENT,
JEFFERSON, OSWEGO, CAYUGA, WAYNE COUNTIES

LEGEND

SHORELAND USES

Commercial, Industrial, Residential and Public Buildings	
Recreational and Urban Open Space	
Agricultural and Undeveloped	
Forest	
Public Beaches	B
Commercial Deep Draft Harbors	C
Recreational Harbors	R
Commercial Deep Draft and Recreational Harbors	C R
Electric Power Stations	P

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

Significant Fish and Wildlife Values	
Unique Ecological or Natural Areas	
Outstanding Shoreland Areas of Possible National Interest	
Potential Recreation Sites	

Waste Water Outfalls and Intakes

Public Outfalls	
Public Intakes	
Private Outfalls	
Private Intakes	

Critical Bird Nesting and Migration Areas 2

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

Federal Lands	
Non-Federal Public Lands	
Private Lands	

Shore type

Artificial Fill Area	A
Erodible High Bluff, 30 ft. or higher	HB_E
Non-Erodible High Bluff, 30 ft. or higher	HB_N
Erodible Low Bluff, less than 30 ft. high	LB_E
Non-Erodible Low Bluff, less than 30 ft. high	LB_N
High Sand Dune, 30 ft. or higher	HD
Low Sand Dune, less than 30 ft. high	LD
Erodible Low Plain	P_E
Non-Erodible Low Plain	P_N
Wetlands	W

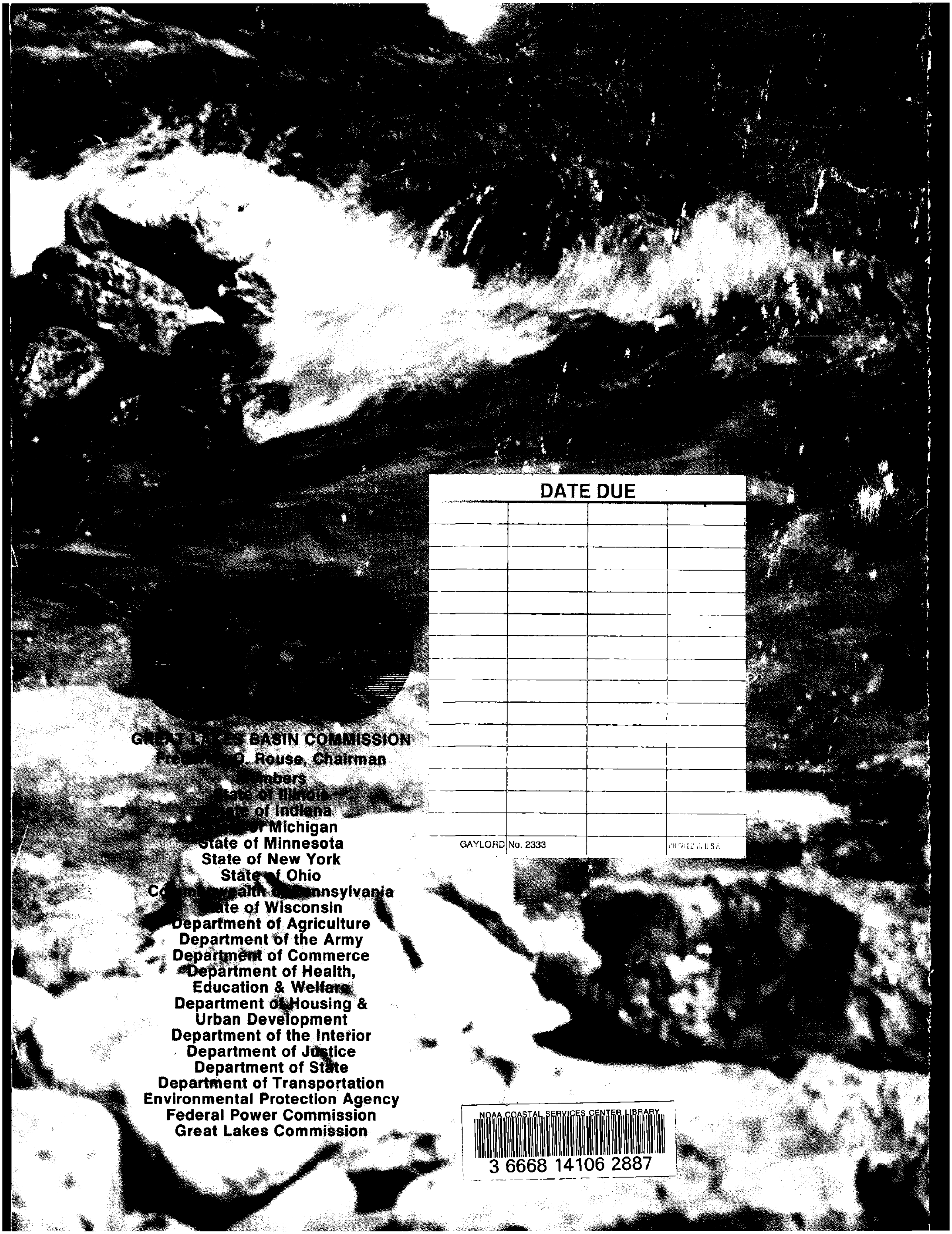
Combinations Shown As:	Example
Lakeward/Landward	W/P_E
Upper Bluff Material / Lower Bluff Material	$\frac{HB_E}{HB_N}$

Beach Material

Sand and gravel	
Ledge rock	
No Beach	

Problem Identification

Areas subject to erosion generally protected	
Critical erosion areas not protected	
Non-critical erosion areas not protected	
Shoreline subject to lake flooding	
Shoreline not subject to erosion or flooding	
Bluff seepage problems	S



GREAT LAKES BASIN COMMISSION
Frederick O. Rouse, Chairman
Members
State of Illinois
State of Indiana
State of Michigan
State of Minnesota
State of New York
State of Ohio
Commonwealth of Pennsylvania
State of Wisconsin
Department of Agriculture
Department of the Army
Department of Commerce
Department of Health, Education & Welfare
Department of Housing & Urban Development
Department of the Interior
Department of Justice
Department of State
Department of Transportation
Environmental Protection Agency
Federal Power Commission
Great Lakes Commission